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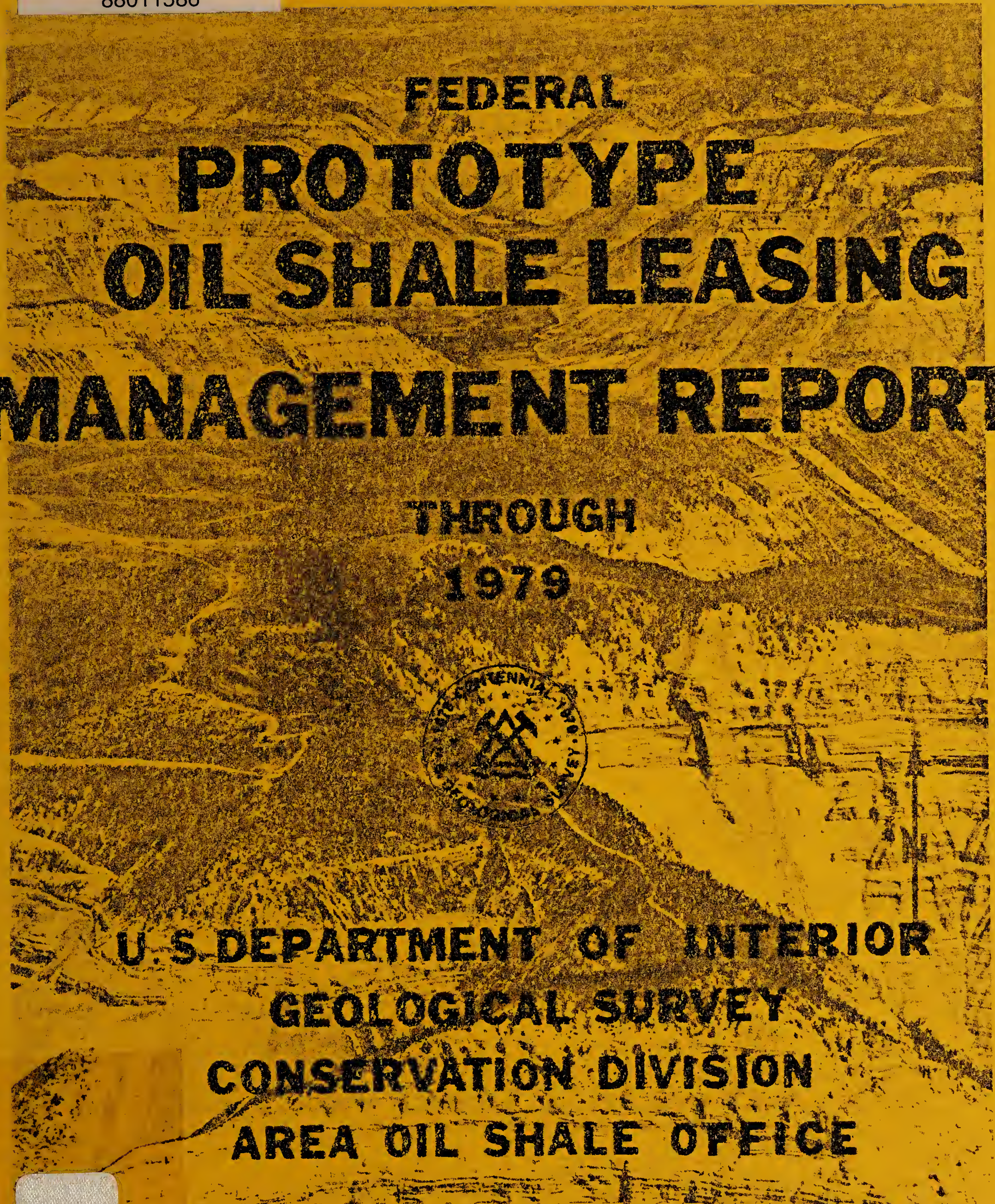

FEDERAL PROTOTYPE OIL SHALE LEASING MANAGEMENT REPORT

THROUGH
1979

U.S. DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
AREA OIL SHALE OFFICE

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PROTOTYPE OIL SHALE LEASING PROGRAM

MANAGEMENT REPORT

1974-1979

By

Staff

Area Oil Shale Office

U.S. Geological Survey

1980

Cover: View toward the north of the Roan Cliffs along Parachute Creek,
Garfield County, Colorado

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PREFACE

The Prototype Oil Shale Leasing Program was announced by the Secretary of Interior in June 1971. The program is designed to test the technical, economic, and environmental feasibility of a domestic synthetic fuels industry based on the vast hydrocarbon resources of Western oil shale deposits underlying public lands in Colorado, Utah, and Wyoming. Upon completion of a programmatic Environmental Impact Statement, six tracts of 5,120 acres each were offered by the Bureau of Land Management for development under competitive lease terms. Four tracts were leased in 1974 (two each in Colorado and Utah). It then became the responsibility of the U.S. Geological Survey's, Conservation Division, and more specifically the Area Oil Shale Office to administer the complex, environmentally orientated lease terms; to establish a cooperative interchange of plans and ideas between industry, government, and the public; to seek ways to minimize possible development effects; and to compile comprehensive environmental, economic, and operations data gathered by the lessees of each tract to aid the Department of the Interior in developing future oil-shale-leasing policy.

This management report has been prepared for the information needs of the public and the Secretary of the Interior under authority contained in Code of Federal Regulations, 30 CFR 231.3(c)(3). It is the first in an annual series documenting programmatic responsibilities and accomplishments, including lease supervision; condition of the leased land; compilation and analysis of environmental, developmental, and operational data for the leased tracts; program chronology; and description of management capabilties developed to effectively supervise oil shale leases on public land. Subsequent reports will update information in each of these areas. Extent of oil shale resources in the western States and production methods are briefly summarized.

Persons interested in further information on the Prototype Oil Shale Leasing Program are encouraged to contact or visit the Area Oil Shale Supervisor's Office at 131 North 6th, Suite 300, Grand Junction, Colorado 81501; or to call (303) 245-6700 (FTS: 322-0281). The U.S. Geological Survey in Grand Junction, Colorado, maintains a wide selection of oil shale documents on open file, including the lessees' development plans, annual reports, and environmental monitoring data. These documents are available for public inspection from 8:00 a.m. to 4:30 p.m., week days. Many of these reports also are available at public and university libraries regional in northwest Colorado, eastern Utah, and at the office of the Oil Shale Environmental Advisory Panel, Room 690, Building 67, Denver Federal Center, Denver, Colorado 80225, (303) 234-3275 (FTS: 234-3275).

Peter A. Rutledge

Peter A. Rutledge
Area Oil Shale Supervisor

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ABSTRACT

This management report on the Prototype Oil Shale Leasing Program was prepared for administrative use of the U.S. Department of the Interior, Geological Survey, and for public information. The report documents programmatic accomplishments since its beginning in 1974 through 1979.

"Oil shale," is a misnomer used to describe a fine-grained sedimentary marlstone that contains approximately 14 weight percent, or more, of solid hydrocarbon called kerogen that can be converted to synthetic crude oil and gas by heating. Oil shales of the Eocene Green River Formation contain an estimated 1.8 trillion equivalent barrels (2.8×10^{11} m^3) of oil and vast quantities of valuable sodium and aluminum carbonate minerals: 64 billion tons (58×10^{13} kg) of trona, a source of soda ash; 29 billion tons (2.6×10^{13} kg) of nahcolite, a source of industrial stack gas scrubbing agent; and 19 billion tons (17×10^{13} kg) of dawsonite - a source of alumina. This fuel and mineral wealth can be recovered by either open-pit or underground mining and by surface or in-situ retorting and processing for recovery of oil, gas, and associated minerals.

Oil-shale retorts were being built in Colorado and Utah beginning in the early 1900's, but it has been only during the past decade that the National energy situation and the evolving oil shale retorting technologies have become economically favorable for commercialization. Within the tricorner area of Colorado, Utah, and Wyoming, 80 percent of the high-grade oil shale lies beneath Federal land. In 1973, the Federal government took the initiative for evaluating the feasibility of commercial shale oil production by initiating and documenting the Prototype Oil Shale Leasing Program (POSLP) in a six volume environmental impact statement, and by the Bureau of Land Management (BLM) competitively leasing four 5,120 acre tracts in 1974 (two each in Colorado and Utah).

Administration of the leases then became the responsibility of the U.S. Geological Survey (USGS) which established a special program office, the Area Oil Shale Office (AOSO), in Grand Junction, Colorado. The Survey was charged with carrying forth four programmatic goals to: (1) provide a new source of energy; (2) develop safeguards to insure environmental integrity; (3) permit equitable return on resource development; and (4) develop management expertise for lease administration. To carry out these actions, the 20 member, multidisciplinary staff of the AOSO has through 1979 completed 466 environmental/development inspections, approved 157 development actions, conducted 17 public hearings, amended lease stipulations three times, and evaluated nearly 300,000 pages of environmental and development monitoring data. The AOSO is assisted in its environmental responsibilities by the Oil Shale Environmental Advisory Panel (convened by the U.S. Department of the Interior in 1974) which has held 28 public meetings.

In accord with lease terms, the lessees of each tract have gathered two years of baseline environmental data against which to assess the effects of development based on data gathered by monitoring programs that will be operated throughout the life of each tract. Lessees' schedules and methods of tract development are described in lease-required Detailed

Development Plans (DDP's) which are approved by the USGS Area Oil Shale Mining Supervisor prior to implementation. DDP's for the two Colorado tracts were approved in the summer of 1977, following public hearings and concurrence of the Assistant Secretary of Interior. Development work on the two Utah tracts is currently enjoined by Federal District Court ruling pursuant to Utah's in-lieu-land-selection suit and conflicting prior mining claims.

To encourage development, the oil shale leases contain economic incentives that allow the last two of the five bonus bid installments payable to the lessor (United States of America) and a portion of initial production royalty payments to be credited against actual development expenditures approved by the USGS Mining Supervisor. Of the more than $448 million bid for the four tracts leased, approximately $269 million in bonus payments had been made by the lessees as of the close of 1979. The remainder has or can be offset (credited) by actual development expenditures. Approximately 37½ percent of the amount paid is returned to the States for use in mitigating socioeconomic impacts. Bonus offsets for $145 million have been granted to the Colorado lessees subject to audit and "actual use" payback agreements. Approximately $72 million in bonus payments (not including interest) for the two leases in Utah are being held in escrow pending final court ruling on the State's land selection suit and conflicting mining claims.

To ensure compliance with lease terms and approved DDP's, the USGS's AOSO staff conduct weekly inspections of development, monitoring, and reclamation operations. Lessees have also been required to establish reclamation bonds and to comply with all other applicable regulations. Due to the complex lease terms and the first-of-a-kind nature of the POSLP, it has proved beneficial to hold regular development and monitoring coordination meetings with the lessees and to establish working level contacts with concerned Federal, State, and local agencies. To effectively evaluate the wealth of operational and environmental data compiled by the lessees, the AOSO has developed a number of formalized inspection, plan, and report review processes. A development/perturbation matrix analysis method has been designed to identify potential environmental impacts.

In-house data management is achieved by encoding all documents to a computer indexed central file according to a numerical system that is keyed to a document's subject and its disposition. Computer facilities are also used to track bonus payments and offsets, to verify production royalty calculations, and, soon, to evaluate environmental monitoring data for trends and effects. All major plans and actions before the AOSO are tracked by a management-by-objective system.

This management report includes lists of permits obtained by the lessees, POSLP milestones, and the location and description of each tract and major on-site facilities. To date, 460 acres have been disturbed by development work on the two Colorado tracts. Approximately 80 percent of this area has been permanently or temporarily reclaimed. Bringing the tracts to commercial operation will require each lessee to obtain nearly 100 different types of permits from more than 20 Federal, State, and local agencies.

The lessees have established a network of biotic and abiotic treatment and control environmental monitoring stations and transects on and about each tract to measure the nature of development effects on air and water quality, meteorology, surface and ground water, wildlife, vegetation, and geotechnical conditions. Monitoring data and the results of the lessees' analyses are reported semi-annually to the AOSO. Major aspects of the monitoring programs are described in this report, together with significant findings to date. These findings suggest that development impacts have been limited largely to areas directly disturbed by construction, the cone of ground-water depression from mine dewatering, flow patterns and channel erosion in adjacent drainages, habitat areas augmented to enhance forage production, increased highway traffic, and community growth.

Data is also routinely gathered on workforce community impacts, health and safety, and development/environmental control costs. Combined workforce on both Colorado tracts averaged 525 persons during 1979. Only one on-tract fatal accident has occurred since the POSLP began through the end of 1979. Community growth has been assisted by lessees' front-end financing of new housing, apartments, and trailer spaces. Community growth needs have also been assisted by use of some of the oil shale lease bonus bid payments returned to the States. Employee busing and van pooling are used extensively between surrounding communities and the tracts to minimize highway congestion and hazards to wildlife. Current development work on each tract is costing nearly $40,000,000 annually.

PROTOTYPE OIL SHALE LEASING PROGRAM

Resource and Development

"Oil shale," a misnomer, is a fine-grained sedimentary dolomitic marlstone containing solid organic matter (kerogen) which when heated will yield synthetic crude oil and gas. Typical composition of a 25 gallon/ton (104 L/kgx10^3) shale is shown in table 1. Domestic oil-shale deposits are widespread, but the richest defined oil-shale resource occurs in the Green River Formation of Colorado, Utah, and Wyoming (figure 1). Kerogen within the oil shale consists of the remains of aquatic organisms, algae, and pollen grains which settled to the bottom of ancient lakes that covered the tristate area some 50-60 million years ago. These deposits are estimated to contain more than 1.8 trillion equivalent barrels (2.8 x 10^{11} m^3) of oil, or about 50 times greater than all known reserves of conventional domestic crude oil. It is currently estimated that approximately 80 billion barrels (1.3 x 10^{10} m^3) of oil can be extracted from the kerogen rich shale by means of available technologies.

Vast quantities of valuable sodium-carbonate minerals are associated with the deep, rich oil shales. There is an estimated in-place resource of 64 billion tons (5.8 x 10^{10} t) of trona (Na_2CO_3), a source of soda-ash in the Green River basin of Wyoming; 29 billion tons (2.6 x 10^{10} t) of nahcolite ($NaHCO_3$), a potential industrial stack gas scrubbing agent; and 19 billion tons (1.7 10^{10} t) of dawsonite ($NaAlCOH_3CO_2$), a potential source of alumina. Both of the latter are principally associated with the oil shale in the Piceance Creek basin of Colorado.

Synthetic crude oil and gas are produced from oil shale by a process called "retorting," whereby the shale is heated to pyrolysis temperature of 800° to 1100°F (400° to 600° C), causing decomposition of the solid kerogen to oily vapors and gas, and leaving behind a residue of residual carbon on the inorganic fraction of the shale.

Retorting can be carried out either in surface facilities or in the ground (in situ). There are two basic types of surface retorts: (1) direct-heated retorts, where pyrolysis heat is provided by combustion of the residual carbon within a moving bed of crushed oil shale; and (2) indirect-heated retorts, which use a working medium that is heated external to the retort vessel and mechanically mixed with the raw shale.

There are also two basic in-situ retorting methods: (1) true in situ, which involves fracturing or dissolving out soluable minerals associated with the in-place shale through boreholes from the surface, and either directly combusting the shale or circulating a working medium heated on the surface; and (2) modified in situ (MIS), which involves removal of 20 to 40 percent of the in-place volume of the oil-shale deposit by conventional mining methods and explosive rubblization of the remaining shale into the mine voids followed by in-the-ground ignition to achieve pyrolysis temperature.

Combustible gas, as well as petroleum liquids, are produced during retorting. Indirect-heated retorts usually produce a high-BTU gas, which can be used similar to natural gas. Direct-heated retorts produce a medium-to low-BTU

Table 1:--Typical composition of 25 gallon/ton oil shale

	Weight-percent
Organic matter:	
Content in raw shale	13.8
Composition:	
Carbon	80.5
Hydrogen	10.3
Nitrogen	2.4
Sulfur	1.0
Oxygen	5.8
Total	100.0
Mineral matter:	
Content in raw shale	86.2
Estimated mineral constituents:	
Carbonates, principally dolomite	48
Feldspars	21
Quartz	13
Clays, principally illite	13
Analcite	4
Pyrite	1
Total	100

From: Prototype Oil Shale Leasing Program Environmental Impact Statement, U.S. Department of Interior, 1973

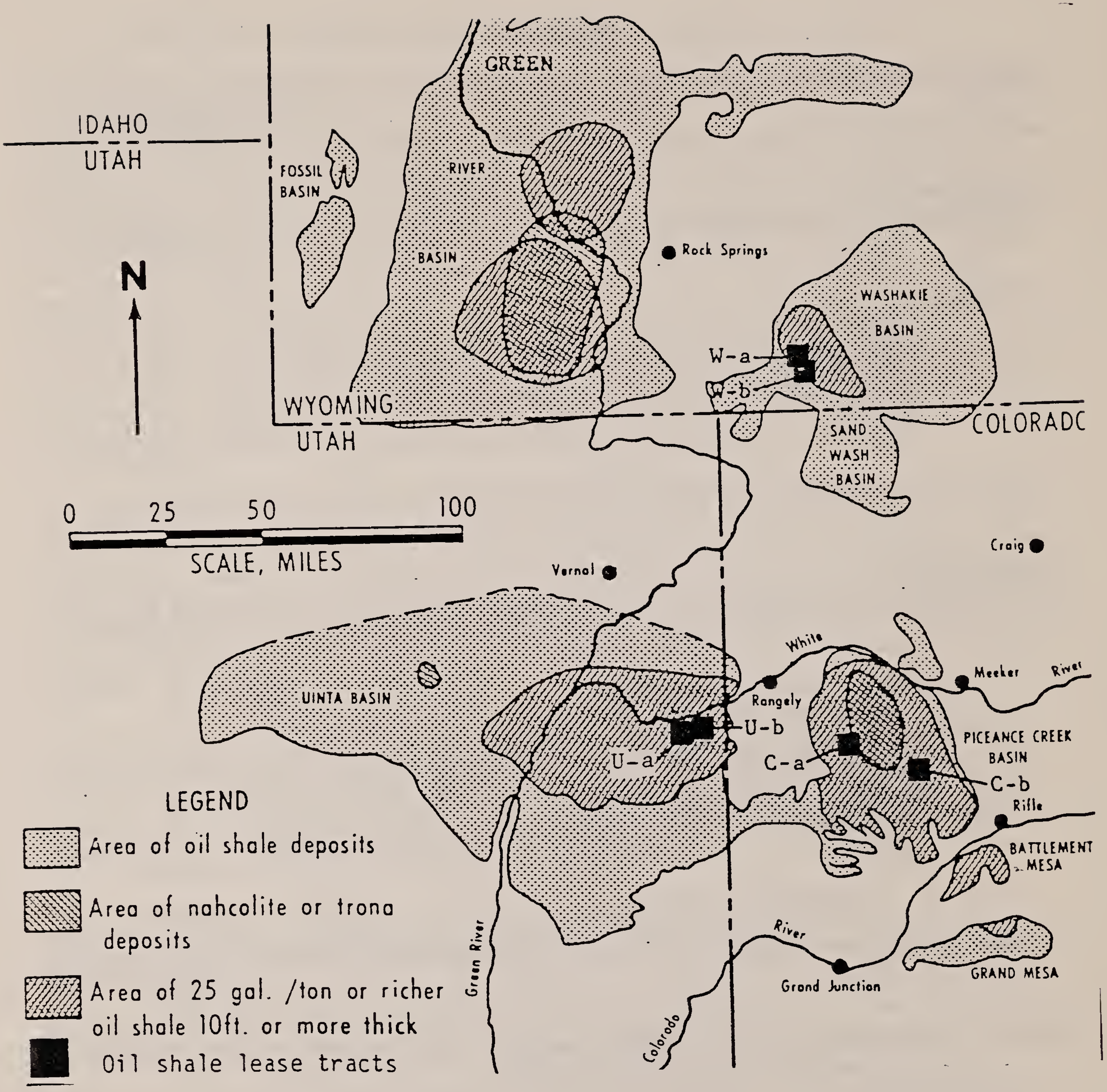


Figure 1. -- Sketch map showing oil shale areas in Colorado, Utah, and Wyoming; and sites of Prototype Oil Shale Leasing Program tracts

From: Prototype Oil Shale Leasing Program Enivronmental Impact Statement, U.S. Department of Interior, 1973 gas owing to dilution by combustion-induced nitrogen and carbon dioxide. The low-BTU gas has potential value onsite where it can be burned either in special boilers to make steam needed in the retorting process or in low-BTU gas turbines to generate electricity.

Oil-shale retorts were being built in Colorado as early as 1917 and in Utah by 1919 (figure 2). By 1925, more than two dozen small oil-shale plants were operating. Shale for these operations was obtained from small pits and mine adits located where the oil shale cropped out. None of these ever produced more than a few thousand barrels of shale oil before being driven out of business by discovery of conventional oil and gas fields. Major research into domestic commercial shale-oil production began in 1945, at the U.S. Bureau of Mines' Anvil Points experimental mine and retort facility, in response to a shortage of fuel during the closing years of World War II. Figure 3 shows the location of current oil-shale research and development operations; table 2 lists the current status of these projects.

The current National energy situation and evolving shale-oil extraction technology have convinced many that now is the time to begin commercial production of shale oil. The minimum commercial size would be approximately 50,000 bbls/day/plant (8000 m^3/day).

Management

History of the Prototype Program

About 72 percent of the 11 million acres (4.5 x 10^6ha) of oil shale land potentially suitable for commercial development in Colorado, Utah, and Wyoming are Federal lands. These lands contain about 80 percent of the high-grade oil-shale resource.

In early 1970, a task force was established within the U.S. Department of the Interior to evaluate the prospects of domestic oil-shale development. Based on the task group's affirmative recommendation and the President's energy policy of 1971, industry nominations were solicited for tract sites on Federal land that have a potential for commercial development, public hearings were held, and concurrence was obtained from the Governors of the three affected States. Terms for leasing and a massive 3,200 page, six-volume environmental impact statement were released in August 1973.

In November 1973, the Secretary of the Interior announced implementation of the Prototype Oil Shale Leasing Program (POSLP). Competitive bidding on the lease sale of six 5,120-acre tracts was begun by the Bureau of Land Management in early 1974 (two each in Colorado, Wyoming, and Utah). Bids were received for the tracts offered in Colorado (C-a and C-b) and in Utah (U-a and U-b) totaling nearly $449 million dollars. No bids were received for the two tracts in Wyoming probably owing to the nature of the low-grade resource.

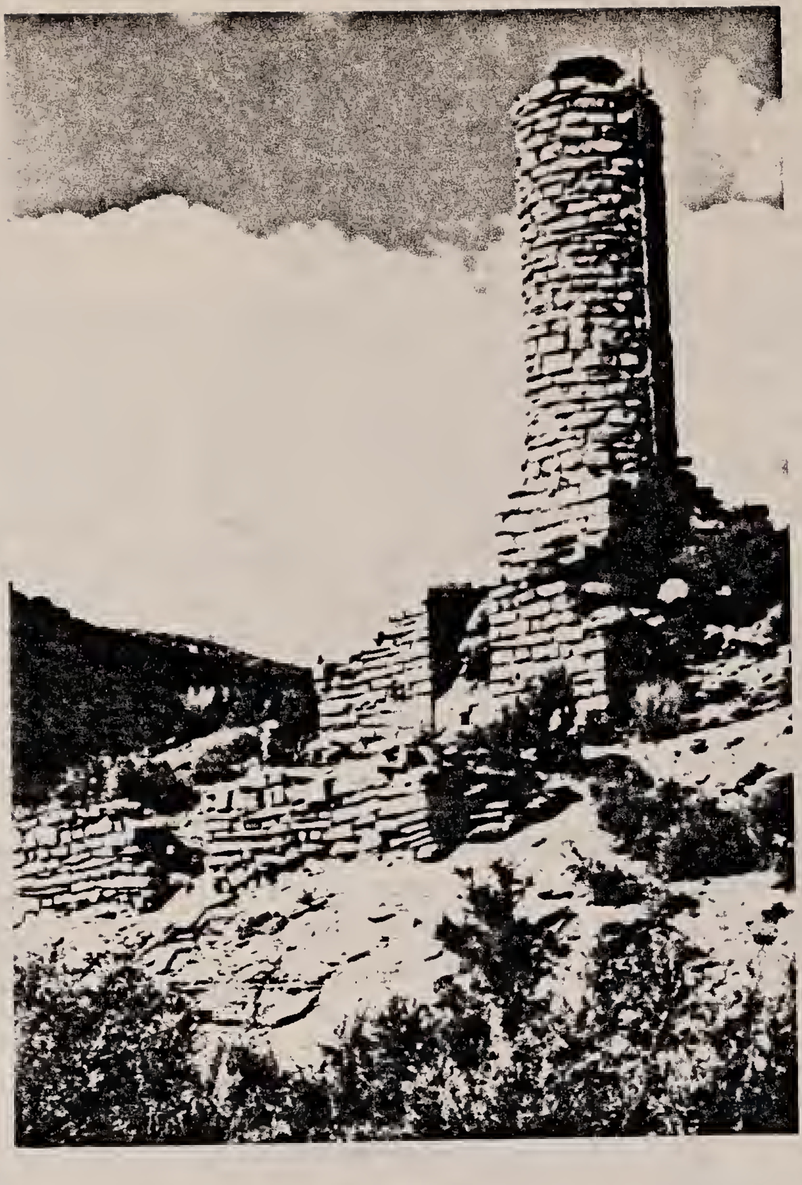


Figure 2.-- Photographs of an early oil shale retort built around 1919 in Agency Draw, south of Vernal, Utah. This retort probably produced less than 10 barrels of shale oil, but is remarkable for its internal mechanical sophistication.

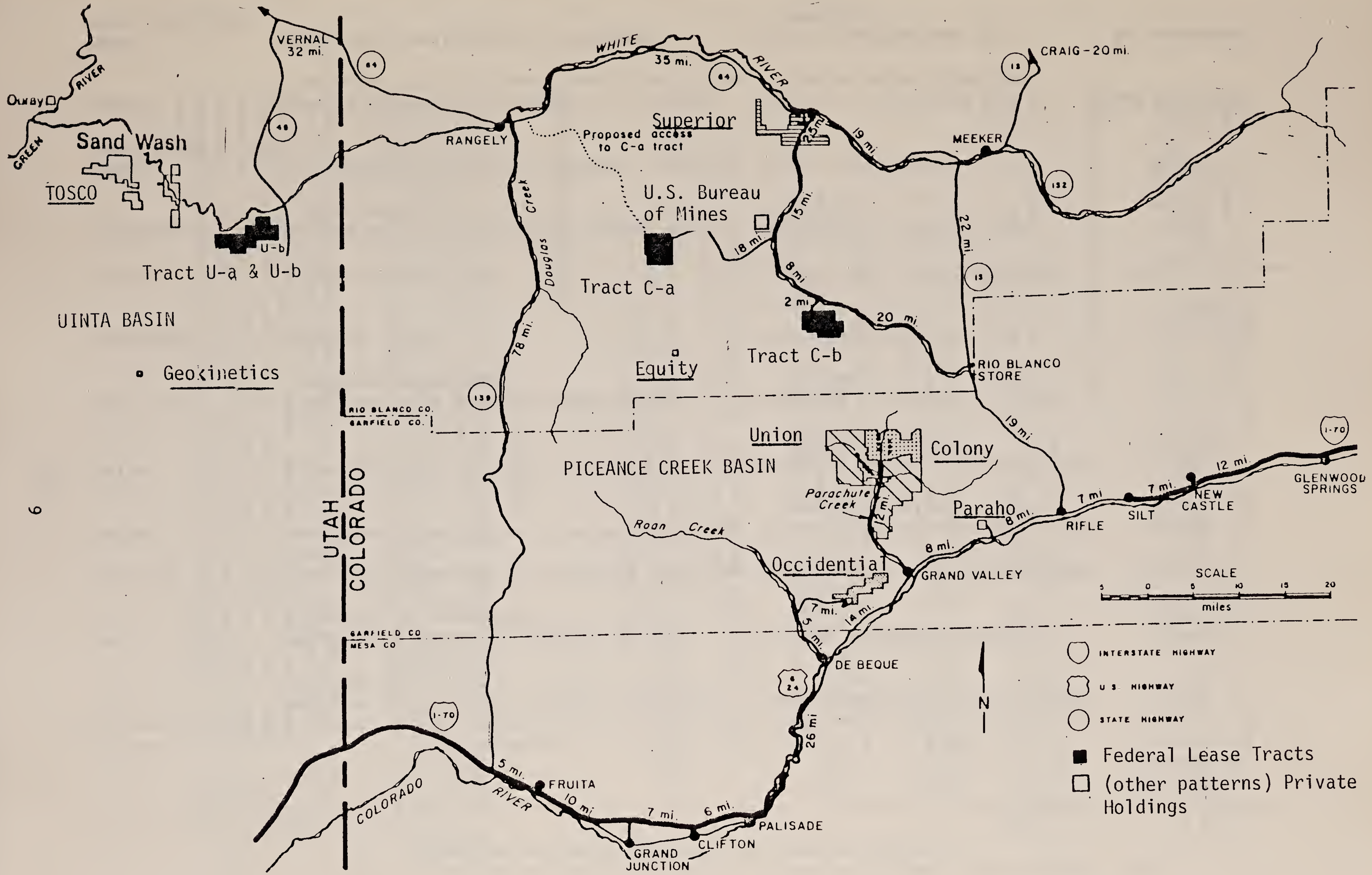


Figure 3. -- Sketch map showing location of Federal oil shale tracts and other oil-shale research and operation sites (names underscored) as of 1979

From: Oil Shale Mining - Plans and Practices (Crockston and Weiss), 1979.

Table 2. -- Status of western oil shale operations and research sites, as of December 1979
(Based on various Government and Industry sources)

Project	Technology	Status	Estimated Production (bbl/day)
C-a	Modified in situ with surface retorting of mined shale	Developing initial test retorts	76,000
C-b	Modified in situ with possible surface retorting of mined shale	Sinking commercial shafts	57,000
U-a, U-b	Room-and-pillar mine with surface retorting	Legal action over land ownership	100,000
Colony	Room-and-pillar mine with surface retorting	Awaiting Federal decision on oil shale incentives	47,000
Union	Room-and-pillar mine with surface retoring	Awaiting Federal decision on oil shale incentives	50,000 - 150,000
Superior	Room-and-pillar mine with multimineral surface processing	Awaiting completion of land exchange	11,600
Occidental	Modified in situ	Developing retorts 7 and 8	No commercial plans
Paraho	Paraho surface retort	Several test runs completed	Several options
Geokinetics	True in situ with formation fracturing and direct-heating	Operation of several small retorts	2,000 per site
TOSCO (Sand Wash)	Room-and-pillar mine with surface retorting	Engineering design	50,000
Equity	True in situ with dissolution of soluable minerals and in-idirect heating with steam	Testing of equipment and limited steam injection	Not announced
USBM (Multi-Mineral)	Underground multimineral development	Initial underground mine sampling	Not announced

After leasing, the administration of the tracts and the terms of the leases became the responsibility of the U.S. Geological Survey (USGS) in accord with Department of Interior management procedures. A special program office was subsequently established in Grand Junction, Colorado, and provided with a 20-member multidisciplinary staff.

Goals of the Prototype Program

The USGS is charged with the responsibility to administer the POSLP within regulatory bounds, lease terms, and sound environmental management practices toward meeting the four programmatic goals as stated by the Secretary of the Interior:

1. To provide a new source of energy to the Nation by stimulating the development of commercial oil-shale technology by private industry;

2. To ensure the environmental integrity of the affected areas and at the same time develop a full range of environmental safeguards and restoration techniques that will be incorporated into the planning of a mature oil-shale industry;

3. To permit an equitable return to all parties in the development of this public resource; and

4. To develop management expertise in the leasing and supervision of oil shale development in order to provide the basis for future administrative procedures.

Lease Administration

Leasing

Authority for leasing under the POSLP comes from the Mineral Leasing Act of 1920 (41 Stat. 437), as amended (30 U.S.C. §. 181-263), subject to regulations in 30 CFR 231 and 43 CFR 23 and Group 3000. Together these provide for leasing of public lands that contain valuable mineral or fuel deposits, including extraction of shale oil and associated economic minerals.

A Notice of Sale was published in the Federal Register on November 30, 1973. The notice indicated that six tracts would be offered for lease through sealed competitive bonus bidding, beginning on January 8, 1974. The successful bid was due in five equal payments. The lease, however, contains a diligent development economic incentive that permits the last two bonus payments and the initial production royalties to be offset by expenditures that are directly related to development of the leased tract.

Role of Bureau of Land Management

Secretarial Order 2948 of October 6, 1972, sets forth the division of responsibilities between the Bureau of Land Management (BLM) and the USGS for the administration of onshore mineral leasing and operating activities, which includes oil shale.

The BLM is responsible for issuing mineral leases and is the office of record in leasing matters. Prior to issuance of the oil-shale leases, the BLM represented the Secretary of Interior in issuing permits for oil-shale exploratory drilling. After the lease is issued and until it is terminated, the USGS is the sole representative of the Secretary in matters relating to the supervision of oil-shale operations. The BLM maintains responsibility for activities on public lands outside the leased area and for non-oil-shale activities, e.g., grazing on the lease sites. The BLM is consulted on the appropriateness of the surface use, environmental protection, and reclamation for all exploration and development plans submitted by the lessees to the USGS for approval.

Role of the U.S. Geological Survey

The USGS has two primary functions: (1) evaluation and classification of Federal lands for their mineral character and value prior to lease or land exchange; and (2) supervision of operations necessary to the prospecting, development, and production of minerals on Federal, Indian lands. Both functions are concerned with discovery, evaluation, receipt of fair market value, efficient development and conservation of leasable minerals belonging to the United States, and restoration of the environmental quality of those lands affected by mineral operations. Lease supervision functions include the responsibility for determining applicable royalty charges and for collecting royalty income on all leased Federal and Indian lands.

Within the USGS, the Area Oil Shale Office (AOSO), was established under the Conservation Division's Central Region to enforce lease terms and to carry out programmatic goals set by the Secretary of the Interior. More specifically, the AOSO functions to ensure that each lessee has (1) carried out a two-year indepth environmental and resource baseline assessment of the tracts and immediate surrounding area pursuant to approved exploration plans; (2) prepared Detailed Development Plans (DDP's) describing how the oil shale resource beneath each tract would be produced; (3) implemented development according to approved plans and schedules; (4) complied with all applicable Federal, State, and local regulations; and (5) established an ongoing program of environmental and operations monitoring and reporting.

The AOSO is operated on a team approach with coordinators for each leased tract. The AOSO staff structure is illustrated in figure 4. Staff personnel function in both a regulatory capacity for lease operations and, equally important, in a coordination/liaison capacity to bring needed outside expertise into the program. The AOSO is greatly assisted in carrying out its environmental management task by the Departmentally convened Oil Shale Environmental Advisory Panel.

Table 3. -- Prototype Oil Shale Program lessees and bonus bid payments as of December 1979
(--, no data)

Lease	Lessee (Operating company)	Lease effective date	Amount bid for lease	Amount of bid paid	Amount of bid offset
		Colorado Tracts			
C-a	Gulf Oil Corp., and Standard Oil of Indiana (Rio Blanco Oil Shale Company)	3/1/74	$210,305,600.00	$126,183,360.00	$ 95,964,093.68[1]
C-b[2]	Occidental Oil Shale Inc., and Tenneco Oil Co. (Cathedral Bluffs Shale Oil Company)	4/1/74	$117,788,000.36	$ 70,672,800.21	$ 49,417,826.89[1]
		Utah Tracts			
U-a	Phillips Petroleum Co., and Sun Oil Co.	6/1/74	$ 75,596,800.00	$ 45,358,080.00[3]	0.00[4]
U-b	Sohio Petroleum (both Utah tracts to be jointly developed by White River Shale Project)	6/1/74	$ 45,107,200.00	$ 27,064,320.00[3]	0.00[4]
		Wyoming Tracts			
W-a	--	5/	--	--	--
W-b	--	5/	--	--	--
Totals			$448,797,600.36	$269,278,560.21	$145,381,920.57

Footnotes on next page

Footnotes for Table 3

[1] While totals for "bid paid" and "bid offset" exceed the "amount bid for lease," only the amount of offset equalling the last two bid payments will actually be credited. The excess will be used to cover credit denied during audit, or can be applied against production royalties due during the sixth through the tenth lease years.

[2] Original lessees of Tract C-b were Ashland Oil, Inc; Atlantic Richfield Co.; Shell Oil Co.; and The Oil Shale Corporation.

[3] Bonus bid payments from the Utah tracts are being held in escrow pending U.S. Supreme Court ruling on State in-lieu-land selection suit.

[4] Application for bid offsets have not been received from the Utah lessees, because of lease suspension under court injunction pending settlement of State in-lieu-land selection suit.

[5] The Wyoming leases received no bids probably because of the restricted resource base for which an adequate return on investment was not then apparent.

Members of the AOSO staff come from many different agencies including the U.S. Bureau of Mines, NOAA, U.S. Forest Service, BLM, Soil Conservation Service, and, in one case, from the U.S. Fish and Wildlife Service by interagency agreement. To supplement permanent staff capabilities, temporary personnel details and contract studies for specific projects are often used.

Management responsibilities of the AOSO in response to lease terms and programmatic goals include:

1. Supervision of on-tract activities in accord with lease terms, applicable regulations, and experience gained. To date, more than 466 inspections have been made of tract environmental monitoring and development activities.

2. Continuous evaluation of DDP implementation on premise that much can be learned to the benefit of current and future oil shale development, and that knowledge gained should be promptly applied. More than 157 changes or revisions were approved during the exploration/ baseline and development phases of the POSLP including three revisions of lease environmental Stipulations.

3. Compilation and analysis of information from the leased tracts to assist in Departmental decisions on oil shale policy and leasing. This has required the AOSO to review and archive nearly 300,000 pages of environmental and development data.

4. Continuing development and implementation of management expertise needed for effective lease supervision. This has involved completion of 12 management guidelines, 9 environmental analyses, 15 public notices, 17 public hearings, 564 bonus credit actions, active participation in 28 Oil Shale Environmental Advisory Panel meetings, and officiating at more than 200 interagency coordination meetings with the lessees.

   Specific duties of the AOSO with regard to each lease include:

   Decision on approval of all exploration, environmental monitoring, DDP's, and related changes;

   Evaluation of all actions, programs, and reports submitted by the lessees;

   Determination of compliance with lease terms, development plans, and applicable laws and regulations;

   Revision of ongoing programs to reflect information gathered and changing regulatory standards; and

   Revision of Oil Shale Lease Environmental Stipulations in accordance with information gathered and advances in environmental management.

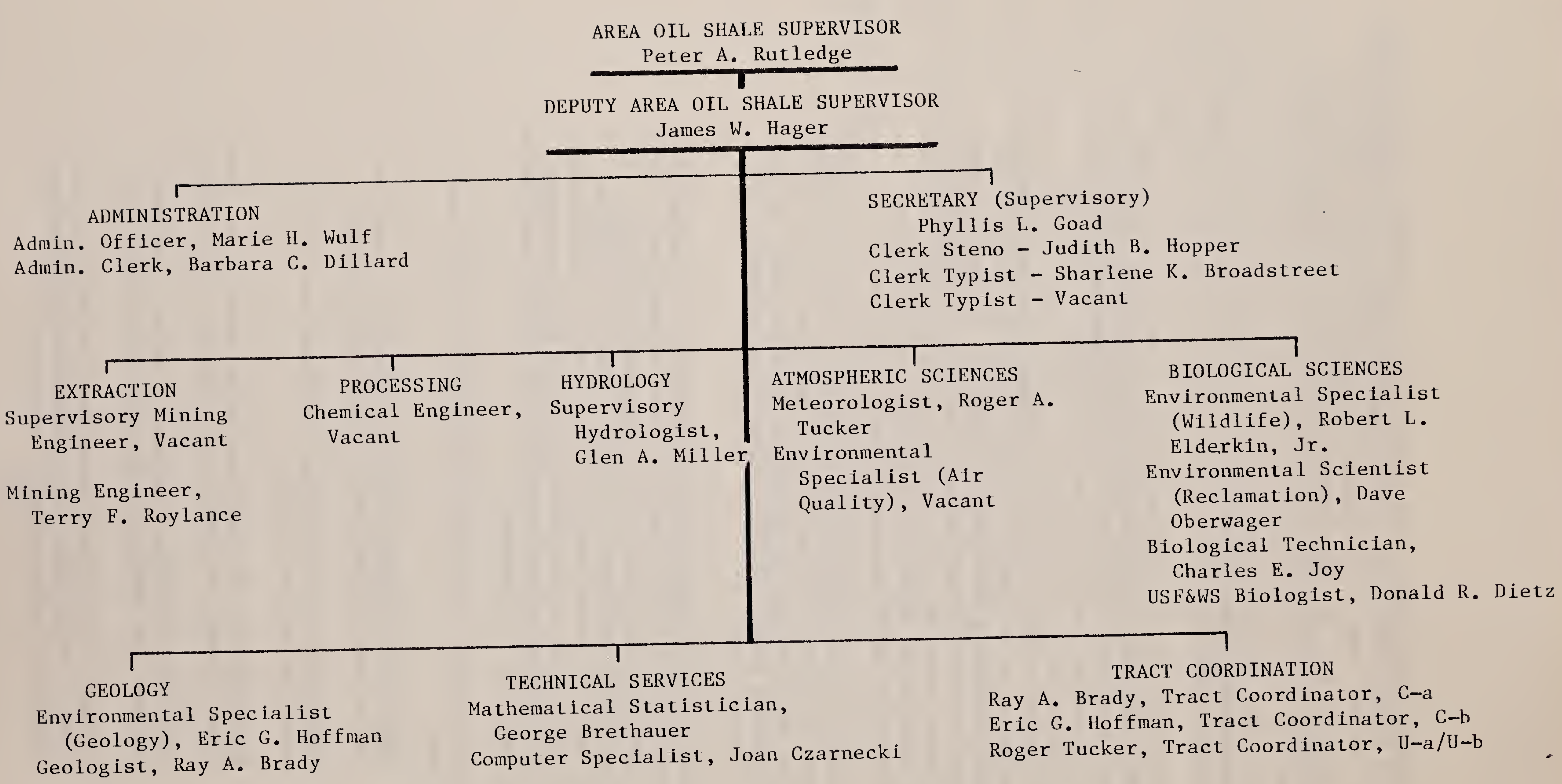

AREA OIL SHALE SUPERVISOR
Peter A. Rutledge
DEPUTY AREA OIL SHALE SUPERVISOR
James W. Hager
ADMINISTRATION
Admin. Officer, Marie H. Wulf
Admin. Clerk, Barbara C. Dillard
SECRETARY (Supervisory)
Phyllis L. Goad
Clerk Steno - Judith B. Hopper
Clerk Typist - Sharlene K. Broadstreet
Clerk Typist - Vacant
EXTRACTION
Supervisory Mining Engineer, Vacant
Mining Engineer, Terry F. Roylance
PROCESSING
Chemical Engineer, Vacant
HYDROLOGY
Supervisory Hydrologist, Glen A. Miller
ATMOSPHERIC SCIENCES
Meteorologist, Roger A. Tucker
Environmental Specialist (Air Quality), Vacant
BIOLOGICAL SCIENCES
Environmental Specialist (Wildlife), Robert L. Elderkin, Jr.
Environmental Scientist (Reclamation), Dave Oberwager
Biological Technician, Charles E. Joy
USF&WS Biologist, Donald R. Dietz
GEOLOGY
Environmental Specialist (Geology), Eric G. Hoffman
Geologist, Ray A. Brady
TECHNICAL SERVICES
Mathematical Statistician, George Brethauer
Computer Specialist, Joan Czarnecki
TRACT COORDINATION
Ray A. Brady, Tract Coordinator, C-a
Eric G. Hoffman, Tract Coordinator, C-b
Roger Tucker, Tract Coordinator, U-a/U-b

Figure 4.-- Organization chart of the U.S. Geological Survey's Area Oil Shale Office (as of 1980)

This management scheme enables the USGS to report, at all times, to the Department of the Interior and to the public on the status of POSLP, lease development, environmental problems, mitigative actions taken, and to assist in future tract selection and oil shale resource evaluation for leasing and land exchange.

Role of the Oil Shale Environmental Advisory Panel

The Oil Shale Environmental Advisory Panel (OSEAP) was established in February 27, 1974. OSEAP's function is to advise the USGS and BLM in the supervision of environmental matters related to lease development, and in the identification and mitigation of environmental hazards. The OSEAP consists of representatives from Interior Department bureaus and offices, other Federal departments, States of Colorado and Utah, counties encompassing the lease tracts, the public, and special interest groups.

To date, the OSEAP has held 28 meetings to evaluate the POSLP and to provide advice on environmental aspects. The panel has also assisted the USGS in conducting public hearings during the review of development plans submitted by the lessees for operations on the oil-shale lease tracts.

Coordination

From the beginning of the POSLP, it was apparent that administration of the complex lease terms and the large scale first-of-a-kind nature of the projects would require close coordination between the lessees and the USGS. Accordingly, a program of monthly working level coordination meetings was established involving representatives from the lessee, USGS, BLM, counties, and agencies that have immediate concerns. At these meetings, status and problems of tract development, environmental monitoring, permit acquisition, lease compliance, and inspection concerns are discussed and mitigative actions formulated. Any necessary changes to development plans are followed up by formal review and correspondence.

Success of the coordination meeting concept has lead to establishment of quarterly meetings to review environmental monitoring programs. The meetings ensure diligence and necessary flexibility in complex monitoring programs, that must be responsive to changes in state-of-the-art and development plans. The review meetings generate open discussions of methodology, problems, data analysis, quality assurance, and interrelationships.

Owing to the multiplicity of regulatory, technical, and special interests engendered by oil-shale development, the USGS has also found it essential to develop working level relationships with a number of Federal, State, and local agencies. Most of the major agencies of concern are illustrated in figure 5.

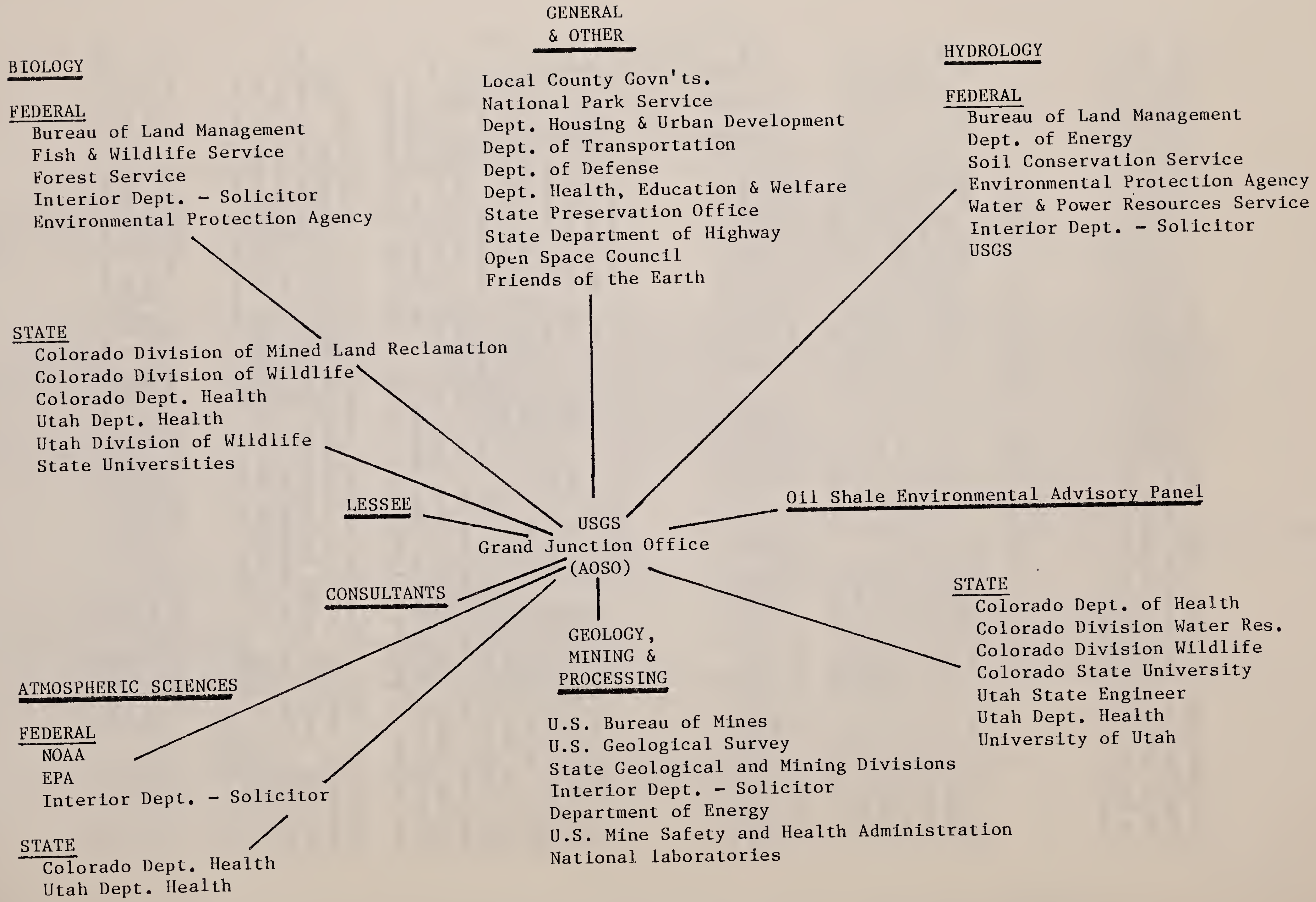

GENERAL & OTHER
Local County Govn'ts.
National Park Service
Dept. Housing & Urban Development
Dept. of Transportation
Dept. of Defense
Dept. Health, Education & Welfare
State Preservation Office
State Department of Highway
Open Space Council
Friends of the Earth
BIOLOGY
FEDERAL
Bureau of Land Management
Fish & Wildlife Service
Forest Service
Interior Dept. - Solicitor
Environmental Protection Agency
STATE
Colorado Division of Mined Land Reclamation
Colorado Division of Wildlife
Colorado Dept. Health
Utah Dept. Health
Utah Division of Wildlife
State Universities
HYDROLOGY
FEDERAL
Bureau of Land Management
Dept. of Energy
Soil Conservation Service
Environmental Protection Agency
Water & Power Resources Service
Interior Dept. - Solicitor
USGS
LESSEE
USGS
Grand Junction Office
(AOSO)
Oil Shale Environmental Advisory Panel
CONSULTANTS
STATE
Colorado Dept. of Health
Colorado Division Water Res.
Colorado Division Wildlife
Colorado State University
Utah State Engineer
Utah Dept. Health
University of Utah
GEOLOGY, MINING & PROCESSING
U.S. Bureau of Mines
U.S. Geological Survey
State Geological and Mining Divisions
Interior Dept. - Solicitor
Department of Energy
U.S. Mine Safety and Health Administration
National laboratories
ATMOSPHERIC SCIENCES
FEDERAL
NOAA
EPA
Interior Dept. - Solicitor
STATE
Colorado Dept. Health
Utah Dept. Health

Figure 5.-- Examples of U.S. Geological Survey's oil shale coordination with other agencies

Lease Requirements

Baseline Program

Prior to starting development work, each lessee was required to complete two years of detailed baseline evaluation of physical and biotic aspects of the tracts and the immediate surrounding area. Data gathered under explorations programs were compiled into baseline reports, against which future development-related impacts could be evaluated. The various exploration/baseline programs had to be approved by the USGS before data could be collected on plants, animals, climatic conditions, air quality, hydrology, water quality, geologic structure and resources, and cultural and scientific values. Most of 1974 was required to develop and approve these programs owing to the extent of lease-required environmental assessment. The baseline program was completed by November 1976.

Detailed Development Plans

After the collection of baseline environmental data, the lease required that each lessee prepare and obtain USGS approval of a Detailed Development Plan (DDP). The DDP must describe baseline conditions and methods that would be implemented for oil-shale-resource development and environmental safeguards. The DDP's were thoroughly reviewed by the USGS for technical completeness and feasibility, compliance with lease and applicable regulations, attention to environmental management, and suitability of planned or demonstrated reclamation technology for disturbed areas. The USGS also consulted with other concerned agencies, held public hearings, received advice on environmental matters from the OSEAP, and obtained concurrence for approval from the Assistant Secretary's office. After a one-year period of suspension of operations to resolve technical and environmental matters, the DDP's for the two Colorado tracts were approved by the USGS in the summer of 1977. The lessees began immediate development work on-tract, subject to continuing USGS inspection.

Either the lessees or the USGS can propose modifications to the approved DDP's at any time to incorporate improved shale-oil-extraction technology, methods for resource conservation, related facilities, and environmental controls. All modifications are subject to approval by the USGS. To date, DDP's for both Colorado tracts have been revised to incorporate changes in shale oil extraction methods.

A DDP was submitted for the joint development of the two Utah tracts. Approval and implementation of that DDP, however, was enjoined by Federal District Court ruling pursuant to Utah's in-lieu land selection suit against the U.S. Department of Interior and other prior claimants to areas encompassing Tracts U-a and U-b.

Environmental Monitoring

Lease environmental stipulations also require the lessee to conduct monitoring during and subsequent to development. The environmental monitoring program must be based on exploration/baseline findings and, thereafter, seek to quantify any changes from baseline conditions and to determine whether such changes are in response to natural trends or directly related to tract development. The complex monitoring programs had to be approved by the USGS prior to implementation. Approved monitoring programs will routinely gather information on several hundred parameters throughout life of operations to quantify interrelated aspects of air and water quality, meteorology, hydrology, flora and fauna, health and safety, geotechnical conditions, and development impacts.

The environmental monitoring programs were phased into the baseline programs during 1978 and early 1979, as tract-development activity began. Problems of implementation and operation of monitoring programs were worked out by the lessees and AOSO at quarterly monitoring review meetings. The approved programs are based on a statistical sampling designed to accept or reject a series of null hypotheses. Monitoring is carried out at essentially two levels (primary and contingency). The contingency-level program will be implemented whenever primary monitoring indicates a rate of change greater than would be considered a natural trend as defined by baseline conditions. Data gathered are compiled by the lessees and reported to the USGS semiannually. Yearly, the lessees analyze the monitoring data and report these findings together with trends and interrelationships, as major parts of their Annual Operations Report to the USGS.

Reclamation

The oil-shale leases contain specific stipulations for reclamation and revegetation of disturbed areas. An approved DDP must include planning, schedules, and methodology for reclamation that will meet all Federal, State, and local regulations. Specifically, the lessee must reclaim all affected lands to a usable and productive condition, consistent with predisturbed and adjacent land uses. Steps must be taken, at all times, to control erosion. In addition, lessees must demonstrate the ability to reclaim disturbed areas within 10 years of DDP approval or cease operations. To this end, the lessees are carrying out extensive revegetation experiment programs in cooperation with private, Federal, and State research groups. Experimental programs are evaluating plant species suitability, planting time, mulching, topsoiling, toxic leachate problems, water harvesting, erosion control, seeding mixtures, mycorrhiza inoculation of soils and seeds, influence of slope and aspects, use of fertilizers, and need for temporary irrigation.

Plan Review and Approval

All exploration, development, monitoring, and reclamation plans, subsequent changes or revisions, and other activities on the leased tracts must be approved by the USGS prior to implementation. To carry out this function thoroughly and expeditiously, the USGS has developed a set of formal review procedures. In general, all plans, changes, and revisions, are subject to detailed staff analysis. Staff review findings, need for supplemental information, and recommendations for approval including specific conditions are compiled on evaluation forms that serve as a permanent record of the in-house review/decision process. During the review process, public hearings are held on all DDP's and major revisions, working level meetings are held with the lessee to iron out plan difficulties, the OSEAP is consulted on environmental aspects, and other concerned agencies are contacted for their input and advice. Staff reviews, public comments, OSEAP recommendations, and agency advice are compiled into summary decision documents for all major approval actions. Routine changes are handled through a similar, although less formal process. The USGS Area Oil Shale Mining Supervisor may consult with Departmental administrators and legal counsel before making a final decision, which is transmitted to the lessee as a written approval or denial together with any specific conditions for plan implementation.

To date, the USGS has completed the following kind and number of major actions related to administration of the POSLP:

- Lease Environmental Stipulations Amended: 3
- Exploration Plans Approved: 3
- Exploration Plans Changed: 75
- Suspension of Operations Issued: 3
- Detailed Development Plans Approved: 2
- Detailed Development Plans Changed: 40
- Monitoring Programs Approved: 4
- Monitoring Programs Changed: 30
- Public Hearings Held: 17
- OSEAP Meetings Attended: 28

Suspension of Operations

To ensure compliance with lease terms and stipulations, adherence to approved DDP's, and to prevent immediate danger to life or irreparable damage to property or the environment, the USGS has the authority to suspend operations on the lease tracts. During the suspension period, the lessee must carry out specific corrective action. To date, it has been necessary to use this authority only infrequently and for limited aspects of tract development to achieve lease and DDP compliance.

The lessee also has the right to request suspension for justifiable reasons of conservation of resource, legal, or environmental constraints. This option was exercised in 1976 when it became obvious that the approved course of development on the Colorado tracts could not proceed due to off-tract land-use constraints, unexceptably low resource recovery, and conflict with Clean Air Act (Prevention of Significant Deterioration) requirements in an area where background levels of certain pollutants exceeded applicable standards. Accordingly, a one-year suspension of operations was granted by the USGS to all lessees to allow relief from lease diligent development and bonus bid payment requirements. During the suspension period, the Colorado lessees prepared revisions to their DDP's for development by MIS retorting as the principal means of obtaining resource conservation in consideration of high-angle jointing and fracturing that impaired rock strength and the unavailability of off-tract areas for waste disposal and plant sites. Legal constraints under the Clean Air Act were also resolved, allowing development to proceed in a way that would not adversely affect ambient air quality.

At the time the suspension period was terminated in mid-1977, development work on the Utah tracts was further precluded by a legal injunction issued by Federal District court over Utah's in-lieu-land selection claim that encompassed the area of the two Federal tracts. No further action has been taken by the USGS to review the lessee's DDP nor can any development work proceed pending outcome of U.S. Supreme Court ruling on the State suit and resolution of conflicting prior claims to these oil-shale lands.

Diligence

The Lease requires each lessee to diligently proceed with orderly development of the tracts and to attain production at as early a time as possible. As an incentive for development, a minimum royalty, based on an escalating production rate, is required by the lease, beginning with the sixth and each succeeding lease year. All development work on the lease tracts is regularly inspected to ensure due diligence and adherence to approved DDP's on the part of the lessees.

The schedule for Tract C-a shows production commencing in 1980 from the Modular Development Phase (MDP) and production from a Commercial Phase in early 1987. The MDP operation includes sequential development of increasingly larger retorts approaching commercial scale. This precludes the lessee from meeting minimum production requirements during the early phase of development, which means the lessee will have to pay the minimum royalty required by the lease out-of-pocket during this period. Commercial phase production, scheduled for 1987, the 13th lease year, is planned to reach 76,000 barrels/day (1.2×10^4) which is significantly greater than the minimum production required by the lease. The USGS has determined that this schedule is a diligent program to obtain production as early as possible at a rate at least equal to the rate on which minimum royalty is calculated.

The schedule for Tract C-b shows production commencing in 1984 from an ancillary facility and commercial production beginning in late 1986. The ancillary phase of development includes the construction of commercial sized facilities and the retorting of several commercial size retorts. Since minimum production requirements are not met during this early phase of development, the lessee must pay the minimum royalty required by the lease. Commercial production is scheduled to begin in late 1986 and will reach full capacity of 57,000 barrels/day (9.1×10^3) by late 1987. This production is significantly greater than the minimum production required by the lease and, therefore, the USGS has determined the schedule to be a diligent program.

Some schedule changes and construction delays have occurred owing to preparation of detailed engineering plans and completion schedules, water control problems, winter construction and material delivery delays, methane and H_2S gas problems, and first-of-a-kind shaft and mine workings development in oil shale. Development is not proceeding on the Utah tracts because of a court issued injunction resulting in an indefinite suspension of operations.

Bonus Offset

The lease contains economic incentives for diligent development. The major incentive allows the last two of five equal lease bonus bid installments to be completely offset by direct expenditures related to development of the leased tract. In June 1975, the Department of the Interior issued a series of guidelines for submittal, evaluation, and approval of bonus offsets (subject to continuing audit). Any approved offsets that exceed the installments due, as shown in table 3, may be deducted from a portion of the production royalty payments due during the sixth through tenth lease years.

By the end of 1979, $145,381,920.57 in bonus offsets had been approved for the two Colorado tracts. This is approximately $14 million more than the last two required bonus bid installments. The excess will be used to cover amounts that may be disapproved during audit or later deducted from initial production royalties after minimum lease required payments are made.

Inspection and Enforcement

Routine inspections are carried out by the USGS to insure compliance with the terms of the lease, environmental stipulations, approved DDP's, and applicable regulations. Areas regularly evaluated include:

- Environmental monitoring and protection
- Road and utility corridors
- Fire prevention and control
- Fish and wildlife management
- Health and safety
- Historic and scientific value protection
- Handling of oil and hazardous materials
- Air pollution control
- Water pollution control
- Noise control
- Rehabilitation and aesthetics
- Vegetation production
- Waste disposal
- Conservation of resource

- Due diligence for development
- Documentation of bonus credits applications
- Verification of environmental data collected

Inspections are conducted weekly or more often as required by the nature of development activities. Special inspections are performed periodically by each AOSO staff member within their his area of expertise. All inspections are unannounced, unless it is necessary to make special arrangements for reasons of required personnel or safety.

The USGS's AOSO has developed formal inspection procedures that emphasizes prompt information exchange with the lessee. These procedures include inviting lessee and contractor representatives to accompany AOSO personnel. At the conclusion of each inspection, an attempt is made to meet with the lessee and prime contractors to go over "items of concern" that do not relate directly to lease terms or approved DDP's and identified lease or plan "violations." For each "item" or "violation," appropriate AOSO staff is contacted to discuss mitigative actions and establish a time frame for their resolution. Finally, all inspections are documented in writing with a copy to the lessee setting forth concerns, violations, and corrective actions. If corrective steps are not taken in a timely fashion, the AOSO may suspend lessee's operations.

A total of 466 multidisciplinary inspections have been carried out by the AOSO since September 1974. Better than 100 inspections were made during 1979, resulting in the issuance of major directives for mine ventilation, mine atmosphere gas sampling, disposal and use of raw oil shale, impoundment construction, and monitoring of quality and quantity of mine water to ensure employee safety and environmental protection. All directives were promptly complied with. The number of inspections will increase significantly as development work reaches a peak during the next several years.

Data Management

Review

The AOSO reviews and archives all environmental and development data generated by the lessees. In addition, the lessees submit a number of special reports including periodic socioeconomic assessments, annual development and environmental monitoring analyses, bonus offset applications, engineering studies, permit applications, and plan modifications. Other agencies such as EPA, Mine Safety and Health Administration, DOE, and State natural resource and mining divisions routinely submit inspection reports and documents generated by oil-shale related studies. These reports and, when possible, raw backup data are reviewed by the AOSO using one of several in-house developed procedures. Assessment of major plans and revisions are summarized on review forms and compiled into decision documents. These and other reviews are used by the USGS Area Oil Shale Mining Supervisor to effectively administer the goals and lease requirements of the POSLP, develop management expertise, act on plans and modifications, respond to public and government inquiries, and assess environmental and development costs. Ultimately, all documents, reviews, correspondence, and decisions are classified for public file, unless they contain proprietary economic, resource, or process information.

Matrix

The USGS has prepared multidisciplinary guidelines to, in part, systematize the environmental monitoring programs conducted on the leased tracts. The "guidelines" are based on the use of:

1. Large-scale base maps and time sequenced mylar overlays depicting approved DDP facilities and location of monitoring transects and stations;
2. A matrix comparing development actions with potential environmental perturbations (Table 4);
3. A matrix comparing potential environmental perturbation with abiotic/biotic response parameters; and
4. A matrix prepared in mirror image to compare all parameters with each other to facilitate estimation of interrelationships.

Matrix parameters were selected for both environmental monitoring and mitigation programs so that trends and significant changes and/or impacts can be evaluated. Examples of some important environmental parameters selected for oil-shale monitoring programs include:

Fauna

- deer distribution and density
- feral horse distribution and density
- composition and density of small mammal populations
- avifauna distribution and density
- threatened and endangered species observations
- general wildlife observations

Flora

- plant condition and stress
- plant cover and density
- plant production and utilization
- plant chemical composition
- threatened and endangered species occurrence
- vegetation types and stage of succession

Aquatic

- benthos biomass and diversity
- periphyton biomass and diversity
- fish (contingency)

DEVELOPMENT-PERTURBATION MATRIX

POTENTIAL PERTURBATIONS

DEVELOPMENT ACTIONS	Creates Surface Disturbance	Creates Noise	Creates Odor	Forms Barrier	Causes Collisions	Creates Dust/Particulates	Emits Gases	Alters Runoff	Creates Erosion	Alters Surface Water	Alters Groundwater	Alters Water Quality	Creates Chemical Leaching	Creates Water Effluents	Creates Seismicity	Creates Landslides/Slumps	Creates Subsidence	Alters Human Activity
MINING																		
Shaft Sinking	●	●				●					●				●			
Drift Development		●				●	●				●				●			
Retorts		●				●	●				●				●		●	
Post Retort							●				●	●	●	●	●		●	
PROCESSING																		
Retorting		●	●			●	●				●				●		●	
Gas Treatment	●	●	Q				●					●	●	●			●	
Steam Generation	●	●	●			●	●					●		●				
Water Treatment	●	●					●				●	●		●				
Oil Treatment	●	●	●				●							●				
Cooling Towers	●	●				●	●					●	●	●				
DAMS & IMPOUNDMENT	●			●		●		●	●	●	●	●	●					
OVERBURDEN & SHALE																		
HANDLING & DISPOSAL																		
Conveyor Belts	●	●		●		●												
Trucks		●	●		●	●	●											
Overburden & Topsoil	●					●		●	●	●	●	●	●				●	
Raw Shale Pile	●					●	Q	●	●	●	●	●	●			●		
Processed Shale Pile	●			●		●	Q	●	●	●	●	●	●		●	●		
TANK STORAGE	●			●			●					●						
WASTE MANAGEMENT																		
Raw Sewage	●		●				●			●	●	●	●	●				
Trash	●		●			●	●				●	●	●					
By-product Waste	●		●			●	●			●	●	●						
POWER GENERATION	●	●				●	●					Q	Q	Q				
UTILITY CORRIDORS																		
Pipe Lines	●																	
Power Lines	●			●	●													
TRANSPORTATION																		
Roads	●			●	●	●		●	●	●	●							●
Vehicles		●			●	●	●											●
MINE WATER																		
Dewatering	●	●	●				●		●	●	●	●	●	●	●		●	
Reinjection	●	●									●	●						
Mine Waste Water												●		●				
Surface Discharge	●	Q	●	●			●	●	●	●	●	●	●	●				
Evaporation			●				●			●		●						
SURFACE FACILITIES																		
Buildings	●							●	●									
Work Areas	●	●	●	●	●													●

Legend: ● = Potential Effect Q = Questionable

Table 4.— Example of a portion of development-perturbation matrix used to predict impacts on ecosystem resulting from oil shale development

Soil-Site

- elevation, aspect, percent slope
- soil series
- soil depth - A and C horizons
- soil temperature
- soil moisture
- soil pH and conductivity
- soil elements, major, minor and trace

Hydrology

- stream and spring/seep flow and quality
- alluvial water levels and quality
- upper and lower aquifer levels and quality
- sediment characterization

Meteorology/Climatology

- air temperature and relative humidity
- precipitation and evaporation
- barometric pressure
- solar radiation
- wind speed and direction
- inversion
- noise

Air Quality

- sulfur dioxide, nitrogen dioxide, and carbon monoxide
- non-methane hydrocarbons and ozone
- total suspended particulates
- size distribution
- trace elements
- gross radioactivity
- carcinogens
- visibility
- plume transport and diffusion

These matrices help USGS specialists to predict general environmental consequences of any combination of development actions. For example, a road through unstable site conditions may result in degradation of slope stability and increased siltation of adjacent drainages. These effects can be predicted by the matrix procedures and the impacts mitigated by actions such as moving the road to more stable alignment, applying soil stabilizers, or planting a vegetation buffer strip to filter out sediment. Matrices are also used to evaluate the design of integrated monitoring and mitigation programs for the many development actions which will take place over the active life of the tracts.

Filing

All correspondence, reports, plans, and other documents received or prepared by the USGS's AOSO are entered into a formal document handling procedure developed with assistance of General Services Administration. Each document is logged by date, origin, subject, and assigned a permanent file number chronologically by year. A special routing, action, and coding form is attached and the document routed to the staff person(s) best able to review, investigate, or prepare needed response. During the routing process a brief abstract of document subject(s) is prepared to which staff members can add further definitions of major subject and cross references by assigning numerical codes selected from a master index. After the document has completed assigned routing, it is filed according to its major code classification and the routing form removed and used to encode a computer index. This computer index can be called up to printout the abstract, document number, and hardcopy file location of all items pertaining to any of nearly 70 major subject areas and 800 cross references. To date, the AOSO has processed better than 14,000 documents (nearly 2,000 in 1979) requiring better than 200 feet of vertical file space for hard copy storage.

Data Processing

The USGS maintains an interactive computer terminal (punch, card reader, line printer, modum, CTR) at the AOSO linked by telephone lines to USGS central computers in Denver, Colorado and Reston, Virginia. This gives the terminal facilities extensive data handling and treatment capabilities. At present, the system is used principally to maintain a complete randomly accessible inventory of all documents passing in and out of the AOSO.

Computer capabilities are also used to track bonus offset applications and approvals. The system will soon be programmed to handle production royalty verifications, material balance calculations, and to evaluate environmental monitoring data for trends and impacts. The interactive terminal can also access other major computer centers and specialized data banks that will be invaluable to effective lease management, such as Colorado State University's Plant Information Network (PIN).

Administrative Support

Office Facilities

The USGS's AOSO was originally housed in temporary space established in the Wayne Aspinall Federal Building in Grand Junction, Colorado. In August 1975, the office moved to its current permanent location on the third floor of the Mesa Federal Savings and Loan building.

The 3,940 square feet of office space is divided into individual staff offices, support staff work areas, conference facilities, file and document storage room, library area, and confidential document storage. An additional 310 square feet of space is used for computer terminal and storage in the basement of the building.

Phone service is provided by four commercial lines, six government FTS lines, and one TIE line to Denver for computer data transmission. The office commercial number is (303) 245-6700 and FTS number is 8-322-0281. A Xerox 400 telecopier is also available for transmittal and receipt of high priority documents.

Field Equipment

To carry out lease inspections and field evaluation of environmental data, the AOSO maintains three four-wheel-drive trucks equipped with radio telephones. One truck is equipped with a camper shell to facilitate round-the-clock inspections. Another is frequently stationed at an airstrip located between the two Colorado lease tracts enabling inspection personnel to use small aircraft to travel to and from the field at an appreciable savings in time and increased manpower efficiency. A sedan is also available for administrative use. Cameras and pocket recorders are used to document inspections and to maintain a slide file encompassing all aspects of tract development and environmental monitoring. Mine safety monitoring instruments are used to spot check in-mine conditions. The office also has a full complement of mine safety equipment to be worn in mines and construction areas.

Clerical Support

The USGS's AOSO clerical staff consists of a secretary, clerk-stenographer, two clerk-typists, and an administrative officer and a clerk. Each is fully knowledgeable of all clerical functions and use of office equipment including word processor, computer terminal, transcribing equipment, copier, and central files. The clerical staff also provides administrative support to the Mining Supervisor's Office in Salt Lake City and clerical services for Oil and Gas Supervisor's personnel stationed in Grand Junction.

Technical Staff

The AOSO technical staff consists of 14 persons with expertise in each of the major biotic and physical sciences affected by oil shale development, including physical and environmental geology, mine engineering, biology and range management, hydrology and water quality, meteorology and air quality, chemical engineering, and reclamation. By experience, this staff is also versed in cultural resource regulations, socioeconomics, royalty accounting, plan review, impact analysis, resource evaluation, interagency coordination, and field inspections.

Such a multidisciplinary staff is necessary to effectively administer the complex environmental lease terms and to deal with the many unknowns that arise in this first-of-its-kind effort to bring western oil shale to commercial production in an environmentally responsible manner. The technical staff will soon be complemented by computer and statistical specialists to enhance its in-house ability to evaluate production and environmental data in order to carry out operational and impact analyses necessary to respond to the major goals of the Prototype Program.

Management by Objective

The AOSO is operated on a Management by Objective (MBO) system geared to respond to conditions in exception to approved plans. All major decisions, reviews, and meetings requiring action by the AOSO are tracked by the MBO system which is updated semiweekly to ensure that all matters are acted on in a timely manner. The MBO system is depicted on a wall size activity control board that is used to guide weekly staff planning meetings.

In addition, it has proven advantageous to diagram decision paths for major plan reviews to ensure adequate time for input from the public, OSEAP, special interest groups, and concerned agencies. Examples of decision/schedule paths for DDP review, approval, and revision are depicted in figures 6 and 7.

Special Projects

Outside Studies

The technical staff of the USGS's AOSO maintains liaison with groups concerned with oil shale development, participates in many outside studies and projects, prepares professional articles, assists in the editing of others, and periodically presents oil shale related speeches or lectures. AOSO staff members also belong to a number of oil shale oriented groups such as The Piceance Basin Ground Water Advisory Committee, The EPA Oil Shale Work Group (associate members), the Water and Power Resources Service (formerly Bureau of Reclamation), Upper Colorado Resources Study Group, and working groups to evaluate air and water data from the Paraho Operations.

Studies and projects in which the USGS's AOSO has been or is involved are listed below; (lead agencies may be contacted for further information).

- Piceance Basin Habitat Management Plan (BLM)
- White River Management Framework Plan (BLM)
- Piceance Basin Ground Water Advisory Committee (USGS)
- Yellow Jacket Multiple Objective Planning Team (Bureau of Reclamation, now Water and Power Resource Services - WPRS)
- Biological Modeling Program (USF&WS/OBS)
- In-Situ Oil Shale Supplemental Leasing EIS (USGS)
- Colony EIS and Land Exchange Mineral Evaluation (BLM)
- Superior EIS and Land Exchange Mineral Evaluation (BLM)
- Central and Southern Utah Regional Coal EIS (BLM)
- Powder River Basin Regional Coal EIS (BLM)
- Quality Assurance Program (EPA)
- Upper Colorado River Resource Study Planning Team (W&PRS)
- Oil and Gas Environmental Analyses (USGS)
- Assisted in preparation and review of oil shale related EARs (BLM)
- Review of Potash EIS (BLM)
- Review potash reserves and calculations for Carlsbad Nuclear

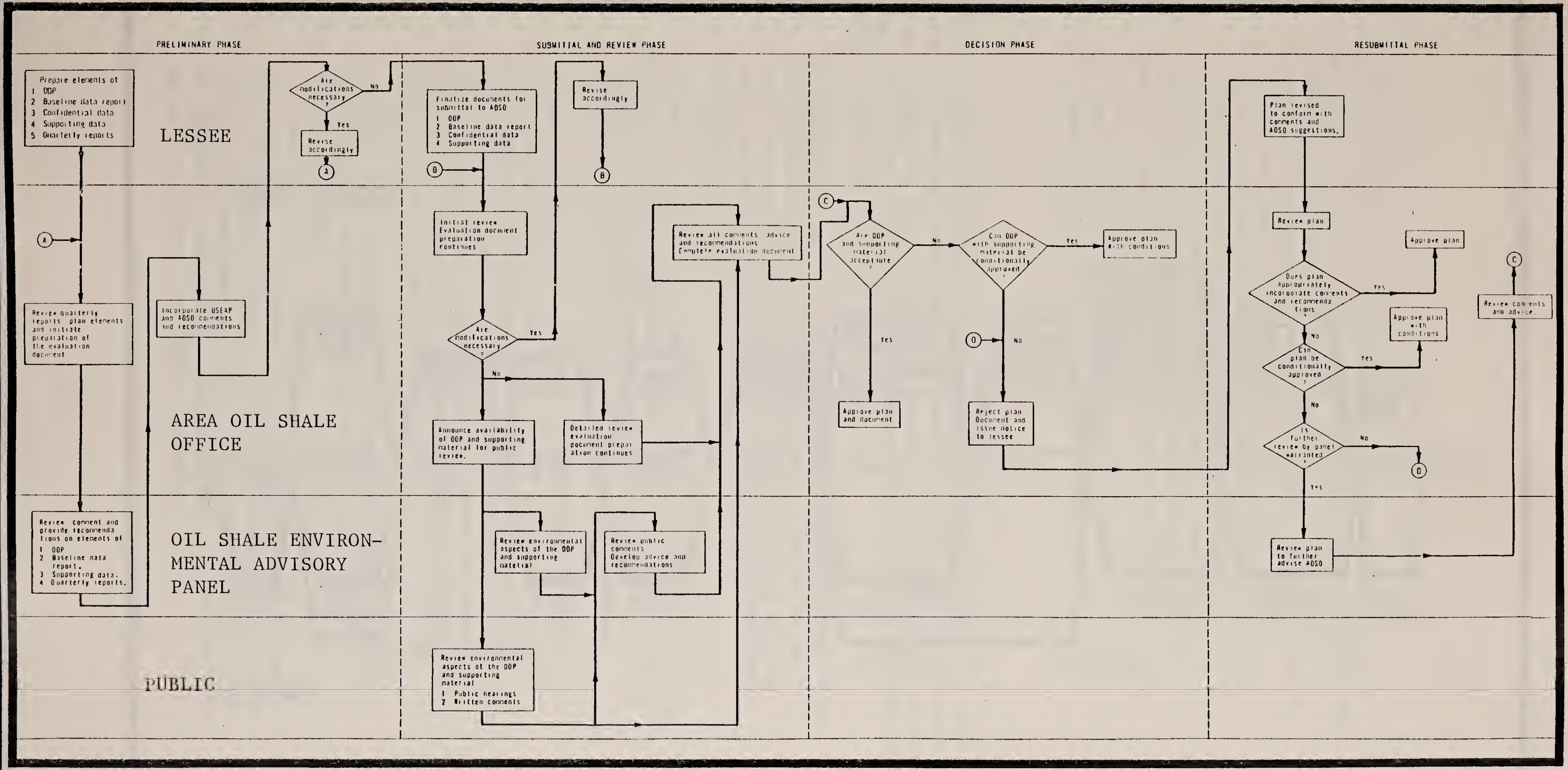

PRELIMINARY PHASE
SUBMITTAL AND REVIEW PHASE
DECISION PHASE
RESUBMITTAL PHASE
LESSEE
AREA OIL SHALE OFFICE
OIL SHALE ENVIRONMENTAL ADVISORY PANEL
PUBLIC
Prepare elements of 1 DDP 2 Baseline data report 3 Confidential data 4 Supporting data 5 Quarterly reports
Review quarterly reports plan elements and initiate preparation of the evaluation document
Review comment and provide recommendations on elements of 1 DDP 2 Baseline data report. 3 Supporting data. 4 Quarterly reports.
Incorporate OSEAP and AOSO comments and recommendations
Are modifications necessary ?
No
Yes
Revise accordingly
A
Finalize documents for submittal to AOSO 1 DDP 2 Baseline data report 3 Confidential data 4 Supporting data
B
Revise accordingly
B
Initial review Evaluation document preparation continues
Are modifications necessary ?
Yes
No
Announce availability of DDP and supporting material for public review.
Detailed review evaluation document preparation continues
Review environmental aspects of the DDP and supporting material
Review public comments Develop advice and recommendations
Review environmental aspects of the DDP and supporting material 1 Public hearings 2 Written comments
Review all comments advice and recommendations Complete evaluation document
C
Are DDP and supporting material acceptable ?
No
Yes
Can DDP with supporting material be conditionally approved ?
Yes
Approve plan with conditions
D
No
Approve plan and document
Reject plan Document and issue notice to lessee
Plan revised to conform with comments and AOSO suggestions.
Review plan
Does plan appropriately incorporate comments and recommendations ?
Yes
Approve plan.
No
Can plan be conditionally approved ?
Yes
Approve plan with conditions
No
Is further review by panel warranted ?
No
D
Yes
Review plan to further advise AOSO
Review comments and advice.
C

Figure 6. -- Decision-making procedure for action on Detailed Development Plans

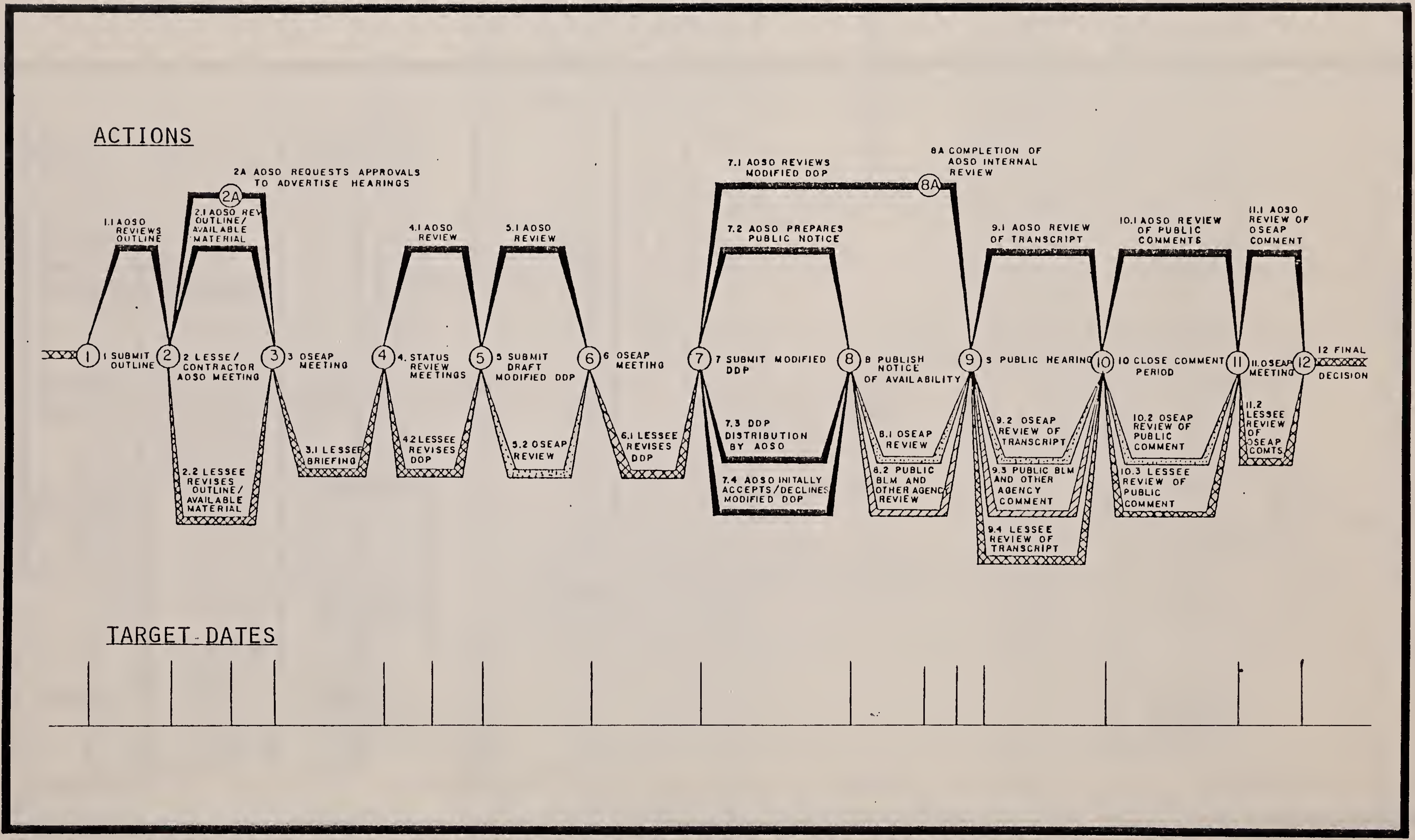

ACTIONS
2A AOSO REQUESTS APPROVALS TO ADVERTISE HEARINGS
2A
1.1 AOSO REVIEWS OUTLINE
2.1 AOSO REV OUTLINE/ AVAILABLE MATERIAL
4.1 AOSO REVIEW
5.1 AOSO REVIEW
7.1 AOSO REVIEWS MODIFIED DDP
8A COMPLETION OF AOSO INTERNAL REVIEW
8A
7.2 AOSO PREPARES PUBLIC NOTICE
9.1 AOSO REVIEW OF TRANSCRIPT
10.1 AOSO REVIEW OF PUBLIC COMMENTS
11.1 AOSO REVIEW OF OSEAP COMMENT
1
1 SUBMIT OUTLINE
2
2 LESSE/ CONTRACTOR AOSO MEETING
3
3 OSEAP MEETING
4
4. STATUS REVIEW MEETINGS
5
5 SUBMIT DRAFT MODIFIED DDP
6
6 OSEAP MEETING
7
7 SUBMIT MODIFIED DDP
8
8 PUBLISH NOTICE OF AVAILABILITY
9
9 PUBLIC HEARING
10
10 CLOSE COMMENT PERIOD
11
11. OSEAP MEETING
12
12 FINAL DECISION
2.2 LESSEE REVISES OUTLINE/ AVAILABLE MATERIAL
3.1 LESSEE BRIEFING
4.2 LESSEE REVISES DDP
5.2 OSEAP REVIEW
6.1 LESSEE REVISES DDP
7.3 DDP DISTRIBUTION BY AOSO
7.4 AOSO INITALLY ACCEPTS/DECLINES MODIFIED DDP
8.1 OSEAP REVIEW
8.2 PUBLIC BLM AND OTHER AGENC REVIEW
9.2 OSEAP REVIEW OF TRANSCRIPT
9.3 PUBLIC BLM AND OTHER AGENCY COMMENT
9.4 LESSEE REVIEW OF TRANSCRIPT
10.2 OSEAP REVIEW OF PUBLIC COMMENT
10.3 LESSEE REVIEW OF PUBLIC COMMENT
11.2 LESSEE REVIEW OF OSEAP COMTS
TARGET DATES

Figure 7. -- Schedule for major Detailed Development Plan revisions

Waste Isolation Project (USGS)

- Reserve Calculations for potash mine abandonment (USGS)
- National Research Council, Committee on Surface Mining and Reclamation, Panel on Oil Shale and Tar Sands (NRC)
- Research proposals and work by EPA, DOE, Bureau of Mines, U.S. Fish and Wildlife Service, etc (each agency)
- Meeker Plant Materials Center Advisory Staff to assist in selection of plant materials for reclamation (SCS)
- Plant Inventory Network (PIN) System to assist in setting up this automated retrieval network (CSU)
- Panel to evaluate Water Quality at Paraho (DOE)
- Oil Shale Work Group (EPA)
- Oil Shale Task Force (DOE)
- Battelle Oil Shale Evaluation Group (DOE)

Contracts

The USGS has provided funds for a number of contract studies in support of the POSLP. Contract assistance for specific projects will continue to be used as needed and will require coordination from the technical staff. Following is a brief description of the contracts which have been fully or partially funded by this office:

1. MITRE Corporation - to develop a Detailed Management Plan for conduct of the Prototype Program. The two major tasks included an outline for DDP's and a plan setting forth the objectives, tasks, procedures, and management structure for the AOSO.

2. Golder Associates - to add to a USBM's contract for a study of water management aspects of oil shale mining and retorting. The USGS funding was for evaluation of true and modified in situ mining and retorting systems.

3. State of Colorado - to provide grant money through the State of Colorado to the U.S. Census Bureau for conduct of a special population count of the three county oil shale impact area (Mesa, Garfield, Rio Blanco counties). Current census data was critically needed to establish population figures for planning in order to assist in mitigation of socioeconomic impacts.

4. Colorado State University - to evaluate plant species best adapted for revegetating soils disturbed by oil shale development.

5. Fish and Wildlife Service - to develop a rapid access plant information network (PIN) as a management tool for planning reclamation projects. The system will be used to inventory vegetation communities and prepare environmental assessments or impact statements.

6. Donaldson Computing and Software - to define a scope of work and preliminary system design for the USGS oil shale environmental monitoring data systems.

7. U.S.G.S., Geologic Division - to evaluate trace elements in oil shale core from Tract C-a. This was a comparative sample evaluation to verify the trace element analyses of a private laboratory.

8. General Services Administration - to evaluate document handling systems for the USGS's AOSO. This task is being funded by the USGS, Office of Assistant Division Chief for Programs, Applied Research and Analysis Section.

Land Exchange

The Department of the Interior has sought to consolidate oil shale lands into developable units through a program of land exchange to eliminate scattered Federal holdings. To this end, USGS and BLM formulated procedures in January 1975 to evaluate proposed oil shale land exchanges. These formal procedures include a mineral and mining evaluation performed by the USGS.

Through 1979, the USGS has been requested to evaluate exchanges proposed by the Colony Development Operation and the Superior Oil Company. The Colony exchange was proposed in January 1973. BLM completed an EIS on the total project in June 1977. The USGS report was requested in July 1977 and completed in December 1977. BLM determined the equal land values in November 1978 and completion of the formal exchange is expected in early 1980. The Superior exchange was proposed in December 1973. The USGS resource evaluation report was requested in February 1975 and completed in February 1976. BLM has prepared a draft EIS on proposed development.

Formal exchange is pending resolution of unequal offered and requested resource values.

Several discussions were held with Carter Oil Company (Exxon) during 1978 and 1979 regarding another oil shale land exchange. Although the USGS has not been formally requested to evaluate the proposed exchange, such a request is anticipated in the near future.

Supplemental EIS

During 1976 and 1977, the USGS led in preparation of a supplemental environmental impact statement for a proposed Departmental In Situ Oil Shale Leasing Program. The Interior Department requested industry nominations for in-situ oil shale development tracts in April 1975. Nine tracts were nominated. These tracts were evaluated in a preliminary draft environmental statement which would have supplemented the 1973 Final Environmental Statement for the POSLP.

The supplemental statement was written by a Departmental task force which included four members of the AOSO. A preliminary draft was released for Department review in March 1977. The Department, however, suspended completion of the supplemental statement and the in situ leasing program was terminated in December 1977, because of a switch to modified in situ technology on Tracts C-a and C-b.

Oil and Gas Activities

The USGS reviews applications for all proposed oil and gas well locations in the oil shale withdrawal area which encompasses a majority of Federal oil shale lands in Colorado and Utah. The AOSO participates in on-site inspections of any locations within one mile of the oil shale lease tracts, and assists the BLM District Manager and the USGS Oil and Gas Supervisor in the preparation of environmental analyses for oil and gas well locations that may impact tract development.

Through 1979, the AOSO has reviewed 124 proposed oil and gas drilling programs in the Piceance Creek and Uinta basins. Many of the oil and gas leases and unit agreements contain special stipulations requiring protection of oil shale. In August 1979, the Area Oil and Gas Supervisor and the Oil Shale Mining Supervisor jointly developed specific casing and cementing requirements for all oil and gas drilling in the Piceance Creek basin. These requirements were necessary for adequate protection of the oil shale aquifers.

Briefings, Presentations, and Articles

Because of the first-of-a-kind nature of the POSLP, there has been a continuing demand for formal presentations, tours, briefings, and papers by the staff of the AOSO. Several "canned" slide presentations have been prepared on the POSLP, environmental monitoring programs, oil shale geology, and on-tract construction and mining activities. The AOSO has also assisted the USGS Conservation Division in the preparation of several mobile displays on the POSLP and illustrated training modules for new employee orientation.

To date, more than 50 formal presentations have been made to groups including the Rocky Mountain Oil and Gas Association, Rocky Mountain Ground Water Committee, Colorado Regional Planning Commission, Club 20, Sierra Club, Colorado Wildlife Society, Federal Executive Development Seminar, Colorado Bar Asociation, Energy Technology Conference, DOE Oil Shale Task Force, Retired Federal Government Employees Association, American Association of Retired Persons, Thorne Ecological Institute, several colleges and universities, local high schools, Grand Junction Rotary Club, Grand Junction Audubon Society, Grand Junction Geological Society, Grand Junction Federal Employees Association, Grand Junction Lions Club, Grand Junction Chapter of AIME, Grand Junction School District staff, and others.

More than 70 briefings and tours have been conducted for Senator Floyd Haskell, Senator Gary Hart, Senate and House Interior Committees, Assistant Secretaries of the Department of Interior, Assistant Secretary of the Department of Agriculture, Undersecretary of the Department of Energy; representatives of the Department of Interior, Department of Energy, Department of Labor, Environmental Protection Agency, U.S. Bureau of Mines, Mine Safety and Health Administration, Department of Defense, U.S. Fish and Wildlife Service, Soil Conservation Service, Office of Management and Budget, General Accounting Office, Office of Technological Assessment, EPA Oil Shale Work Group, Sierra Club, Governors Advisory Group, Colorado Energy Council, Colorado Division of Wildlife; and several local and national newspapers, television news agencies, and foreign visitors.

Approximately 15 papers have been prepared by the USGS's AOSO staff for presentation at the National Western Mining Conference, Water for Energy Development Seminar, DOE Statistical Symposium, Rocky Mountain Ground Water Conference, National Mitigation Symposium, IGT Oil Shale Symposium; meetings of the Society of Range Mangement, American Geophysical Union, American Association of Petroleum Geologists; and at the University of Cincinnati, Colorado State University, Oak Ridge Associated Universities, Utah State University, and Brigham Young University.

Public Information

Requests for environmental monitoring and development data, data analysis reports, and general oil shale information occur daily. Some requests are answered easily over the telephone, while others may require several hours of research and compilation of information. Requests for information are routinely received from members of Congress, private individuals, environmental groups, government agencies, private industry, university students and faculty, and research groups. To maximize the use of the vast amount of data generated by the POSLP, a special effort has been made to send relevant data reports to agencies who have concerns or expertise in areas critical to oil shale development. All monitoring and development data collected by the lessees are submitted to the USGS and in turn are provided to interested agencies and persons. File copies are maintained for public inspections at the AOSO and selected summary reports are sent to region libraries.

CHRONOLOGY

The following chronology lists major administrative and development milestones of the Prototype Oil Shale Leasing Program.

June 29, 1971	Prototype Oil Shale Leasing Program (POSLP) was announced by Secretary of the Interior. - A preliminary environmental statement, program statement, and state reports on oil shale were released. - Industry informational corehole drilling was authorized.
November 2, 1971	Department of Interior requested oil shale lease tract nominations. Twenty tracts were nominated.
April 25, 1972	Six tracts were selected for leasing (two each in Colorado, Utah, and Wyoming).
August 29, 1973	Final environmental impact statement on the POSLP was submitted to CEQ, including: - Regional impacts of a one million barrel-per-day industry. - Anticipated impacts from development of the six selected lease tracts. - Methods of shale oil production including conventional underground and open-pit mining with surface retorting, and in situ processing of oil shale.
January-June 1974	Prototype oil shale lease sales were held as follows:

Lease	Sales Date	Effective Date	Original Lessees**
C-a	1/8/74	3/1/74	Gulf, Standard (Indiana)
C-b	2/12/74	4/1/74	TOSCO, ARCO, Shell, Ashland
U-a	3/12/74	6/1/74	Phillips, Sun
U-b	4/9/74	6/1/74	White River Shale Project
W-a	5/14/74	*	—
W-b	6/11/74	*	—

*The Wyoming leases received no bids primarily because of the restricted resource base.

**See table 3 for listing of current lessees, bonus bid, and amount paid and offset to date.

February 27, 1974 Oil Shale Environmental Advisory Panel (OSEAP) was established by the Department of Interior and the first meeting was held on April 15, 1974. Purpose of the OSEAP is to:

- Provide for public participation; and
- Advise Interior officials, particularly the Area Oil Shale Supervisor and BLM District Managers, on the environmental aspects of the POSLP.

June 1974 Area Oil Shale Office (AOSO) was established within the Conservation Division, Central Region of the U.S.G.S., to administer the POSLP.

May-August 1974 Exploration and environmental baseline data plans were received from the lessees of the four prototype lease tracts.

- These plans were reviewed and approved with conditions by October 1974.
- Environmental baseline data collection commenced in the fall of 1974 and the required two years worth of data were completed by the end of 1976.

December 23, 1975 TOSCO and ARCO withdrew as Tract C-b lessees stating that inflation, economics, and lack of government incentives made development of the lease unattractive. Shell and Ashland, the remaining lessees, continued work toward submittal of a Detailed Development Plan (DDP).

March-June 1976 Lessees submitted lease required DDP's as follows:

Tract	Date	Development Methods
C-a	March 1976	Open pit mining with indirect heated surface retorting.
C-b	Feb. 1976	Underground mining with indirect heated surface retorting.
Ua/Ub	June 1976	Underground mining with direct and indirect heated surface retorting.

	- Over 200 copies of each DDP and related reports were distributed to OSEAP, interested agencies, individuals, and libraries.
March-July 1976	Lessees applied for Suspension of Operations pursuant to Section 39 of the Mineral Leasing Act and the Oil Shale Lease. - Tract C-b applied on March 4, 1976. - Tract C-a applied on July 2, 1976. - Lessees of Tracts U-a and U-b applied for a suspension on July 19, 1976. On September 27, 1976, the lessees withdrew their original suspension application and submitted a new application.
August-October 1976	Suspensions of operations were granted for Tracts C-a and C-b in August 1976 and for Tracts U-a and U-b in October 1976 for the following reasons: - All tracts: Data from the baseline air quality program showed that natural background amounts of non-methane hydrocarbons, ozone, and particulates on occasion exceeded National Ambient Air Quality Standards (NAAQS). EPA was consulted and worked on this issue during the suspension period. - Tract C-b: On-tract geotechnical program revealed that rock strength was less than assumed from mines on the basin margins which would decrease resource recovery by room-and-pillar mining to an unacceptable degree. - Tract C-a: Open pit development of this tract required the use of off-tract disposal sites. The Solicitor determined that the Department of Interior did not have authority to grant use of off-tract lands. Bills were introduced in Congress to authorize the use of off-tract lands.
November 2, 1976	Shell Oil Co., withdrew as a Tract C-b lessee. The remaining lessee, Ashland Oil, announced on November 4, 1976, a partnership with Occidental Oil Shale Inc., for the purpose of using Oxy's modified in situ technology to develop Tract C-b.
December 21, 1976	Environmental Defense Fund, Colorado Open Space Council, Friends of the Earth, and Denver Audubon Society filed suit against the Department of the Interior questioning the basis on which suspension of operations was granted.

	- This suit was dismissed based on the omission of indispensable parties and improper jurisdiction.
March 1, 1977	Tract C-b lessees submitted a modification to the DDP changing the direction of development from room-and-pillar mining with surface retorting to OXY's modified in-situ (MIS).
May 18, 1977	Lessees of Tracts U-a and U-b filed suit against the Department of Interior seeking an injunction to indefinitely suspend lease due diligence requirements and bonus payments until conflicts with overlapping mining claims and State in lieu land selection of the leased areas were resolved. - A hearing on a preliminary injunction was held on June 3, 1977, and continued to June 8, 1977, when the injunction was granted.
May 25, 1977	Tract C-a lessees submitted a revision to their DDP changing the direction of development from open pit mining with surface retorting to MIS with surface retorting of development rock.
May 1977	Tract C-a lessees submitted an application to extend suspension of operations beyond the September 1, 1977, expiration date, because the issue of NAAQS had not yet been resolved.
July 5, 1977	Regional Administrator for EPA Region VIII provided a technical support document as basis for an administrative opinion by EPA that presently measured air quality concentrations on the oil shale tracts do not preclude the development of the tracts' resources. This resolved the NAAQS issue eliminating it as a valid issue for extending suspension of operations.
August 9, 1977	Interior Department Assistant Secretary for Energy and Minerals was provided technical review documents and a draft approval letter prepared by the AOSO for modification of the Tract C-b DDP and asked to concur in the Mining Supervisor's preliminary determination that the revised DDP be approved. Similar material was submitted for revision of the Tract C-a DDP.
August 30, 1977	Interior Assistant Secretary for Energy and Minerals concurred in approval of the modified DDP for Tract C-b and the approval letter was formally signed by the Mining Supervisor and the lessees. The letter contained 12 specific conditions regarding environmental protection, monitoring, water management, abandonment, and submission of engineering plans.

September 1, 1977	One year Suspension of Operations for Tracts C-a and C-b were terminated and the request for an extension by the lessees of Tract C-a was denied.
September 22, 1977	Interior Assistant Secretary for Energy and Minerals concurred in the approval of the Revised DDP for Tract C-a and the approval letter was formally signed by the Mining Supervisor and the lessees. The letter contained 11 specific conditions regarding environmental monitoring, shale disposal, emission modeling for commercial phase, shale leachability, and submission of engineering plans.
December 6, 1977	Environmental Defense Fund, Colorado Open Space Council, and Friends of the Earth filed suit in United States District Court of Colorado seeking to enjoin development of Tracts C-a and C-b. Claimants felt that NEPA requirements had been violated and that approval of the DDP's and related rights-of-way should be overturned until a site specific EIS was prepared.
January 1978	American Mine Service Company, contractor for Rio Blanco Oil Shale Company (Tract C-a) began sinking the 15-foot diameter Service/Production shaft. This shaft will be used primarily during the Modular Development Phase (initial test retorts). A ventilation shaft and a secondary escape/service shaft will be upreamed after completion of the Service/Production shaft.
February 1978	A contract was let by the C-b Shale Oil Project (Tract C-b) to Gilbert Corporation to sink four shafts on Tract C-b (a 34-foot diameter Service shaft, 29-foot diameter Production shaft, 15-foot diameter Ventilation/Escape shaft, and 10-foot diameter Temporary Off-Gas shaft). Shafts will be about 2,000 feet deep. Work began later that month on the Service and Production shafts, and in May on the Ventilation/Escape shaft. By December 1979 the shafts had been deepened to 744, 833 and 1,017 feet respectively. Use of formation grouting and full concrete lining has significantly limited ground water inflow to about 100 gpm in each shaft.
April 1978	Approval subject to audit was given to bonus offsets for Tracts C-a and C-b totaling more than required fourth bonus payments.
May 1978	American Mine Service Inc., completed the open work steel headframe on Tract C-a over the 15-foot diameter Service/Production shaft. The headframe will be used for both shaft sinking, and for mine and retort development.

August 8, 1978	U.S. Court of Appeals ruled in favor of the State of Utah's claim to over 157,000 acres of in-lieu land selections encompassing Tracts U-a and U-b. On September 22, 1978, the Department of Interior filed a motion for rehearing before the Tenth Circuit Court which upheld the lower court ruling. This enjoined the Federal Government from enforcing lease terms on the Utah tracts and placed them under indefinite suspension of operations. Limited environmental monitoring was continued. The Department of Interior has appealed the case to the U.S. Supreme Court.
August 1978	Weyre Construction Corp., completed the 178-foot high concrete slipformed Service Shaft hoist tower at the Mine Support Area on Tract C-b. The tower was completed in 10 days of continuous pouring and will house hoisting equipment for lowering workers and equipment into the commercial mine beneath Tract C-b.
August 25, 1978	Judge Finesilver, of the U.S. District Court, issued a summary judgment dismissing the December 6, 1977, suit filed by the Environmental Defense Fund, Colorado Open Space Council, and Friends of the Earth. The court held that the 1973 EIS for the POSLP was sufficient for DDP and rights-of-way approval, and that procedures of the AOSO were more than adequate to fulfill the requirements of NEPA. This summary judgment was appealed by the Plaintiffs.
September 1978	Ruscon, Becon and Associates, and The Industrial Company began work on the Tract C-a MDP retort product treatment plant.
October 1978	Weyre Construction Corp., completed the 313-foot high concrete slipformed Production shaft hoist tower at the Mine Support Area on Tract C-b. The tower, with walls no less than two feet thick, was raised in 26 days of continuous pouring and will house hoisting equipment for commercial mine and retort development.
December 15, 1978	Ashland Colorado, Inc., announced withdrawal from Tract C-b effective February 14, 1979. This left Occidental Oil Shale, Inc., as the sole lessee. Ashland indicated that withdrawal from the C-b Project was prompted by economic studies that suggest increased capital and operating costs may reduce profitability in the face of technical, political, and regulatory uncertainties.
December 1978	Western Slope Gas Company completed installation of a 4½-inch natural gas service pipeline to Tract

	C-b. Natural gas will be used for on-tract electrical power generation for shaft sinking and related facilities. A majority of this power load will be switched to a 138 KVA powerline to be built from Meeker, Colorado, to Tract C-b. A similar pipeline was completed into Tract C-a in August 1979.
April 1, 1979	Tenneco Oil Company acquired half interest in Tract C-b with Occidental Oil Shale, Inc. Tenneco paid $110 million for half interest in the project and will share costs 50-50 after April 1.
March-April 1979	Lessees submitted their first detailed Annual Reports (for 1978 operating year) summarizing initial development and monitoring including analyses of environmental data through the baseline period.
April 1979	Approval subject to audit was given to bonus offsets for Tracts C-a and C-b totaling more than required fifth bonus payments.
June 1979	American Mine Services Inc., completed the 10-foot diameter 830-foot deep raise bored Ventilation/Exhaust shaft on Tract C-a.
June 1979	Drilling began for placement of rubblizing charges to create the first MDP MIS retort chamber (Retort 0) on Tract C-a. The 30'x30'x170' high retort will be ready for ignition by late 1980.
October 1979	American Mine Service Inc. completed the 15-foot diameter concrete lined Service/Production shaft on Tract C-a to a depth of 979 feet. The shaft will be used to develop initial in-situ retorts, hoist mined rock, and move men and equipment.
November 29, 1979	Environmental Defense Fund filed an appeal to the U.S. District Court ruling which was contrary to their motion to have approval of DDP's for the two Colorado tracts overturned until a site specific EIS was prepared.
November 30, 1979	Mine Health and Safety Admimistration declared the mine on Tract C-a to be "gassy" due to two minor methane ignitions in areas where cutting torches were in use. On January 2, 1980, the C-b shafts and limited mine workings were also declared gassy due to methane measurements in mine ventilation air.
December 5, 1979	U.S. Supreme Court heard the Federal Government's appeal to the August 8, 1978, 10th District Court of Appeals ruling on Utah's in-lieu land case. No final ruling has yet been handed down.

PROTOTYPE TRACTS

Tract Location

Federal Oil Shale Tract C-a (Lease No. C-20046) is located in the Piceance Creek basin, Rio Blanco County, Colorado, 58 miles (43 km) northwest of Rifle and 51 miles (82 km) southwest of Meeker, Colorado. Tract C-b (Lease No. C-20341) is also located in the Piceance Creek basin, Rio Blanco County, Colorado, 40 miles (61 km) northwest of Rifle and 40 miles (61 km) southwest of Meeker. The two Utah tracts, U-a and U-b (Lease No.'s U-25918 and U-26194), are located in the Uinta basin, Uintah County of northeastern Utah, 42 miles (68 km) southeast of Vernal, Utah, and 30 miles (48 km) southwest of Rangely, Colorado.

Tract locations are depicted in figures 1 and 3, and are more particularly described as follows:

Colorado

Tract C-a

T.1 S.,R.99 W.,6th P.M.,
    Sec. 32, E½,E½W½;
    Sec. 33, all;
    Sec. 34, W½,SE¼,W½NE¼,SE¼NE¼
T.2 S.,R.99 W.,6th P.M.,
    Sec. 3, all;
    Sec. 4, all;
    Sec. 5, E½,E½W½(incl. lots 1, 2, and 3);
    Sec. 8, E½;
    Sec. 9, all;
    Sec. 10, all.

The area described aggregates 5,089.7 acres (2,061.3 ha).

Tract C-b

T.3 S.,R.96 W.,6th P.M.,
    Sec. 5, W½SE¼,SW¼;
    Sec. 6, lots 6 and 7,E½SW¼,SE¼;
    Sec. 7, lots 1, 2, 3, and 4,E½W½,E½;
    Sec. 8, W½NE¼,NW¼,S½;
    Sec. 9, SW¼;
    Sec. 16,NW¼,W½SW¼;
    Sec. 17, all;
    Sec. 18, lots 1, 2, 3, and 4,E½W½,E½.
T.3 S.,R.97 W.,6th P.M.,
    Sec. 1, S½;
    Sec. 2, SE¼;
    Sec. 11, E½;
    Sec. 12, all;
    Sec. 13, N½;
    Sec. 14, N½NE¼.

The area described aggregates 5,093.9 acres (2,063.0 ha).

Utah

Tract U-a

T.10 S.,R.24 E.,S.L.M.,
Sec. 19, E½;
Sec. 20, all;
Sec. 21, all;
Sec. 22, all;
Sec. 27, all;
Sec. 28, all;
Sec. 29, all;
Sec. 30, E½;
Sec. 33, N½;
Sec. 34, N½.

The area described aggregates 5,120.0 acres (2,073.6 ha).

Tract U-b

T.10 S.,R.24 E.,S.L.M.,
Sec. 12, S½,S½N½;
Sec. 13, all;
Sec. 14, all;
Sec. 23, all;
Sec. 24, all;
Sec. 25, W½W½;
Sec. 26, all.
T.10 S.,R.25 E.,S.L.M.,
Sec. 18, all;
Sec. 19, all.

The area described aggregrates 5,120.0 acres (2,073.6 ha).

Location and Description of Operations

Following pictures, diagrams, and tables depict the location and type of facilities constructed on Tracts C-a and C-b and the area disturbed and reclaimed through 1979. The overall development scheme for each tract is briefly described together with a tabulization of major surface structures and mine workings.

Tract C-a

Development Scheme

Tract C-a is under lease to the Rio Blanco Oil Shale Company (a general partnership of Gulf Oil and Standard of Indiana). Approved DDP's call for development in essentially a two-phased approach using modified in-situ (MIS) methods adapted for moderately deep overburden (less than 1,000 feet (305 m)). The initial or Modular Development Phase (MDP) will result in construction and operation of three MIS retorts increasing from 166 feet (51 m) in height with 30 by 30 foot (4 x 9 m) cross section to near commercial size of 400 feet (122 m) high with 60 by 150 foot (18 by 46 m) in plan dimensions, and a temporary retort off-gas and product oil treatment plant (figure 8). Additional retorts may be rubblized and burned during the MDP if additional data is needed. Commercial phase retorts will be approximately 700 feet (214 m) tall and up to 200 feet (61 m) in cross section.

Individual MIS retorts will be developed using bore holes drilled from the surface for emplacement of rubblizing explosives from bottom to top of the planned MIS retort chamber. Explosives will be detonated in stages from the bottom upward. After initial blasts, shale rubble equal to approximately 40 percent of the volume of the retort chamber will be drawn out the chamber bottom through the mine production level, hoisted to the surface by a skip operating in the Service/Production shaft and stockpiled for probable future above ground retorting. Once rubble equal to the required void volume is withdrawn from the bottom of the retort chamber, remaining oil shale will be explosively broken to fill all but a narrow attic at the top of the chamber. The boreholes will then be used for lowering igniters into the top of the retort chamber and to supply air and steam to sustain and control the retorting process.

The northern portion of the tract will probably be developed first followed by the southern half with barrier pillars left along the complex NW-SE trending fault system that essentially divides the tract in two. Life of operations will be from 20 to 40 years depending on whether both northern and southern portions of the tract are retorted. MIS operations with surface retorting could recover 1.7 to 2.5 billion barrels ($2.7 \times 10^8 m^3$ to $4.0 \times 10^8 m^3$) or 20 to 30 percent of the inplace shale oil resource over the breadth of retorted zone. The development scheme is conceptually depicted in figures 9 and 10, except the intermediate mine levels in Figure 11 will not be developed.

Due to overburden of moderate depth, Tract C-a could be developed by open pit mining methods. This would nearly double the estimated resource recovery to 58 percent of the inplace shale oil over the depth of the pit. Such an approach was originally proposed by the Tract C-a lessees, but was abandoned due to economic reasons and the need for off-tract sites for initial overburden deposition and surface retorts. The Department of Interior, however, does not currently have authority to grant the lessees off-tract land-use.

During 1979, production and ventilation shafts were sunk, and the lower most (production) mine level was advanced toward the site of the first MDP retort (Retort 0). Construction of a temporary retort off-gas treatment plant and associated water handling and oil storage facilities were also nearly completed in 1979. Work was started on expansion of mine and well dewatering systems to essentially "dry up" the MDP retort area.

Production from Retort 0 is anticipated by late 1980. Maximum production rate during the MDP is estimated to be 750 bbl/day ($119 m^3$/day) or 50,000 barrels ($8 \times 10^3 m^3$) total. If each succeeding scale-up of MDP retort size and anticipated production rate is successful, and if market conditions appear favorable, the lessees may elect to expand operations to commercial scale of 76,000 bbl/day ($1.2 \times 10^4 m^3$/day) by the late 1980's using a combination of MIS and surface retorting.

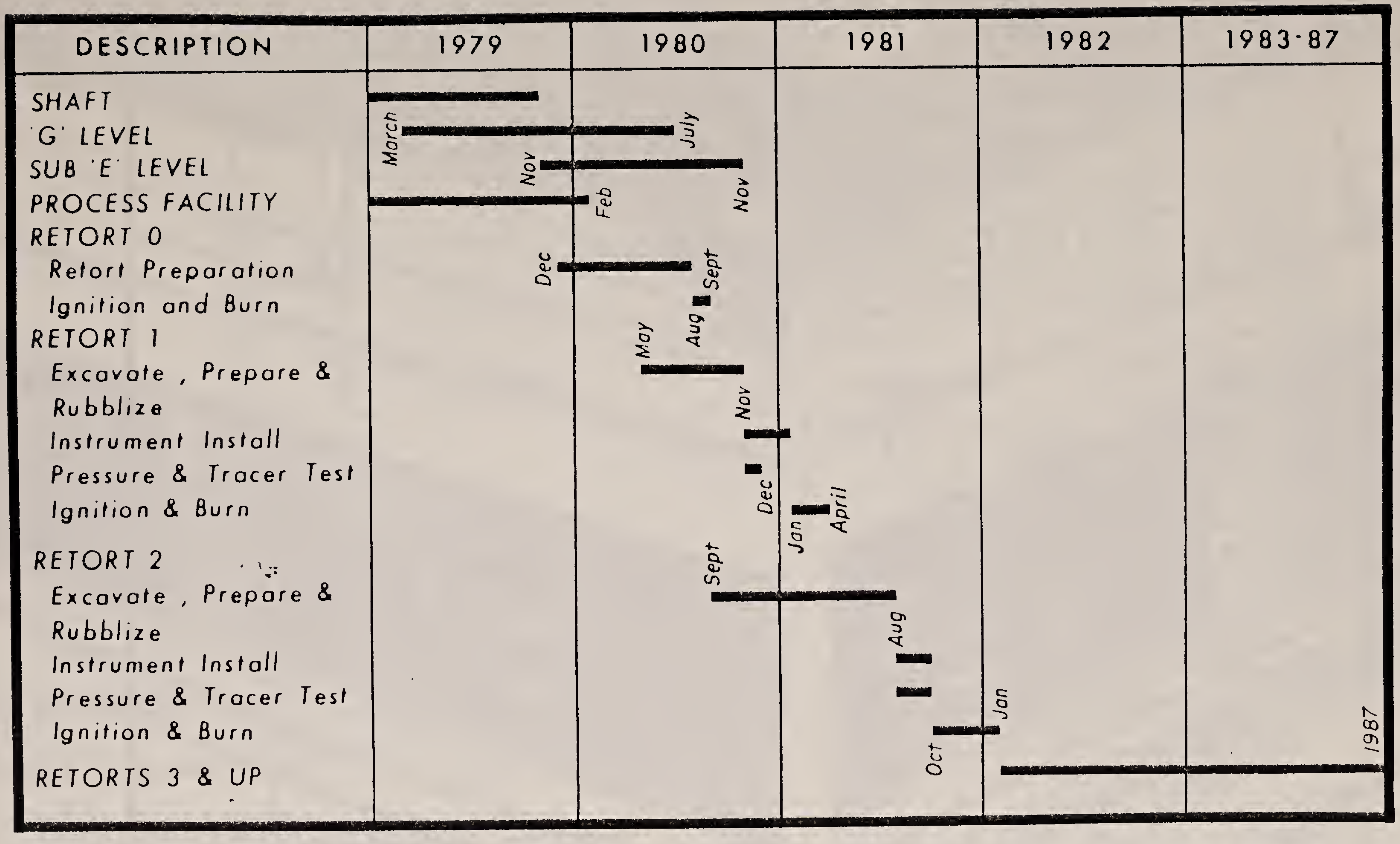


Figure 8. -- Schedule for Tract C-a Modular Development Phase Retorts

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

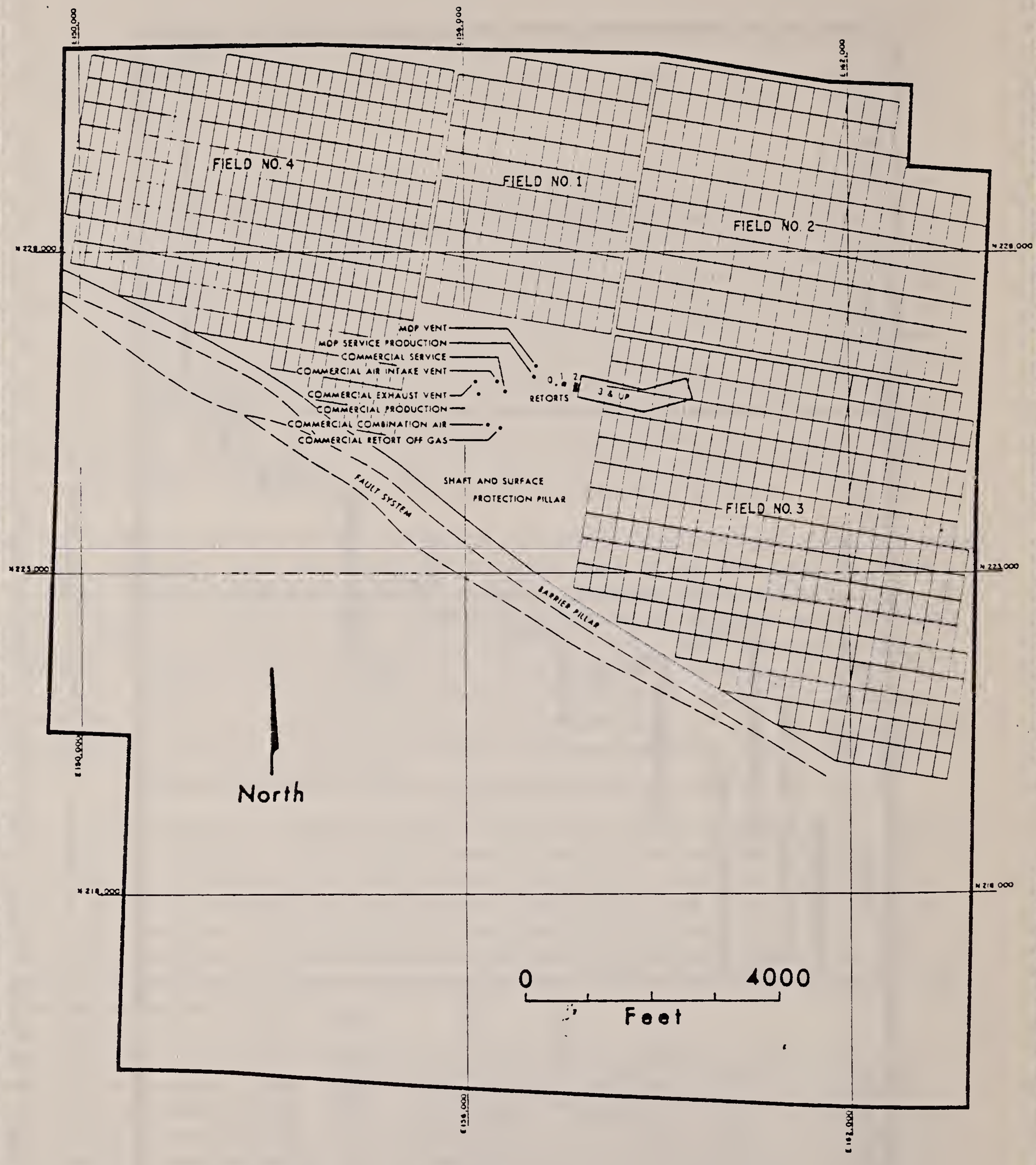


Figure 9. -- General retort layout for initial tract C-a commercial development

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

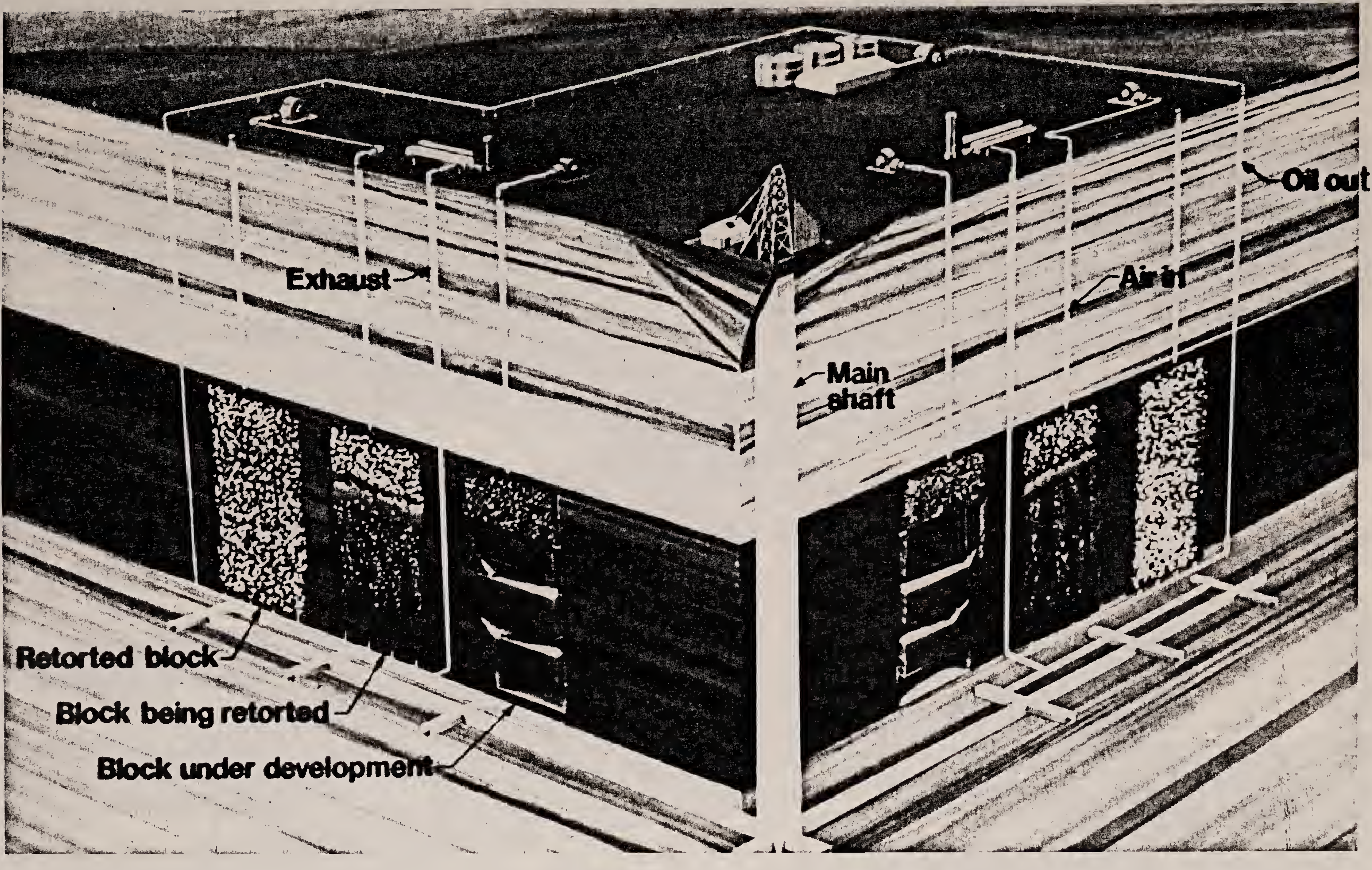


Figure 10.-- Conceptual drawing of Tract C-a modified in-situ retort development scheme (retort chambers will be rubblized by explosives placed through surface boreholes rather than from multiple mine levels as depicted)

From: Rio Blanco Oil Shale Company, 1978.

Major Facilities

Major surface and mine facilities constructed through 1979 on Tract C-a are briefly described below. Their plot relationship is shown in figures 11 and 12.

Facility	Description
Access	Tract C-a is reached by 13 miles (21 km) of paved two-lane County Road #24 which connects with the Piceance Creek Road (Rifle - 58 miles (93 km), Meeker - 51 (82 km), Rangley - 68 (109 km)). There are 1½ miles (2.4 km) of paved road on-tract to the Mine Development Area. Existing dirt roads and trails are used to access other tract sites.
Employee transportation	Approximately 90 percent of on-tract employees ride in van and car pools.
Earthwork	931,000 cubic yards ($7.1 \times 10^5 m^3$) of earth were moved to create a 60-acre (24 ha) Mine Development Area. From that area, more than 30,000 cubic yards ($2.3 \times 10^4 m^3$) of soil and subsoil were stockpiled for use in future reclamation. An additional 92 acres (37 ha) have been disturbed for construction of access, soil storage, impoundments, mined rock disposal, borrow areas, utilities, and the like (figure 13, table 5).
Natural gas line	A 4-inch (10 cm) natural gas service pipeline was laid to the tract for standby power generation, space heating, MDP retort kindling, and processing operations.
Powerline	Twelve on-tract diesel generator sets were replaced by a 22-mile long (35 km) 138 KVA transmission line from the Moon Lake Electric Association's Rangley-to-Meeker line to provide power for mine hoists, ventilation, pumping, general lighting, and shop power. A 2,500 KW standby generator set provides emergency backup. Power is delivered on-tract through buried cables.
Communications	A limited six channel microwave telephone link to Grand Junction was replaced by an 18-line buried telephone cable from Meeker routed through an 80-channel on-tract PBX and two way FM mobil units. Installation is underway on an Unicom VHF pilot advisory system for nearby airstrip.
Security	Guard building, security personnel, and 11,000 feet (3,400 m) of three-strand barbed wire fence are used to restrict unauthorized persons,

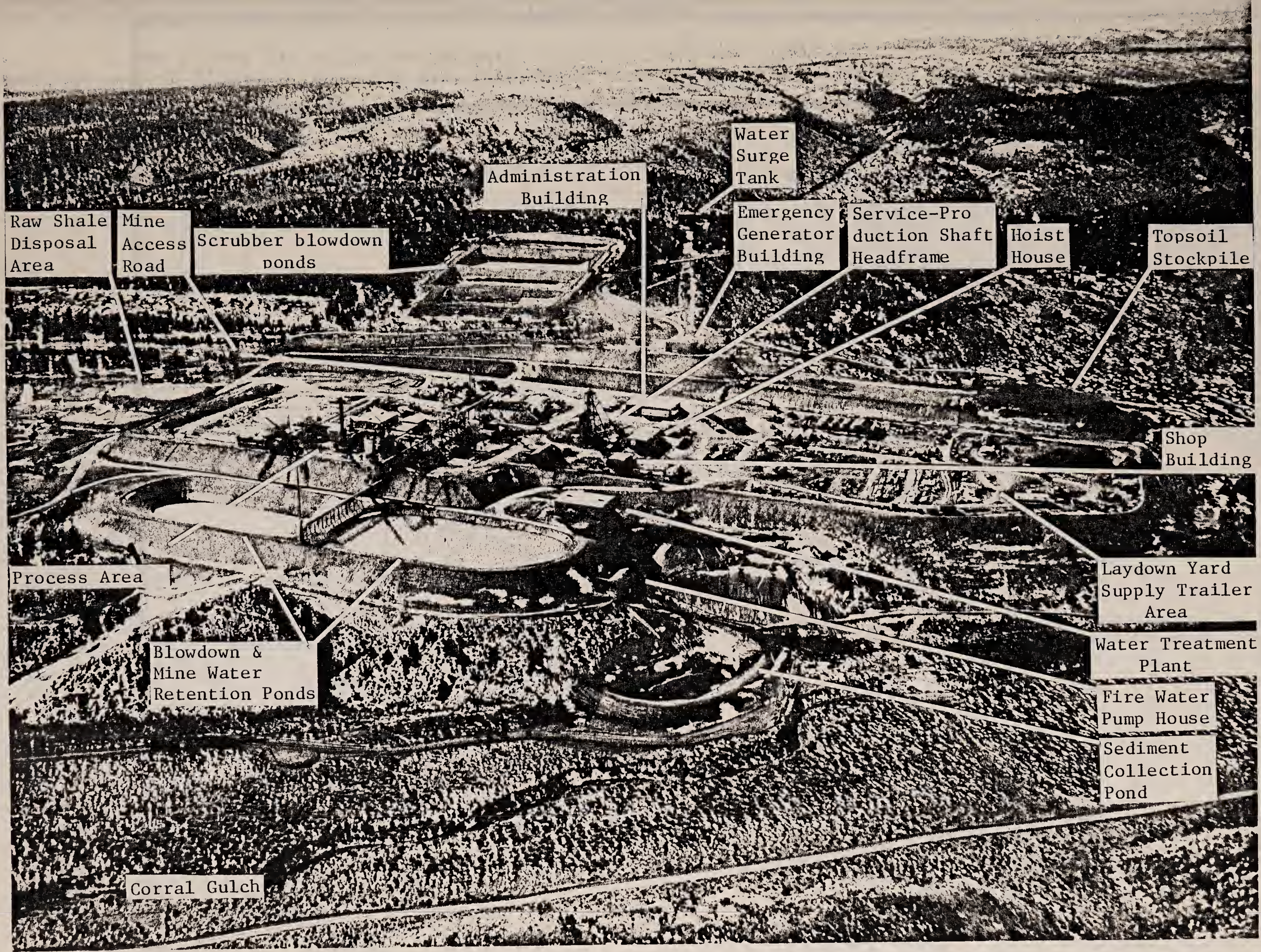


Figure 11. -- Aerial photograph of Tract C-a Mine Development Area, and Modular Development Phase retort off-gas treatment and product oil collection facility

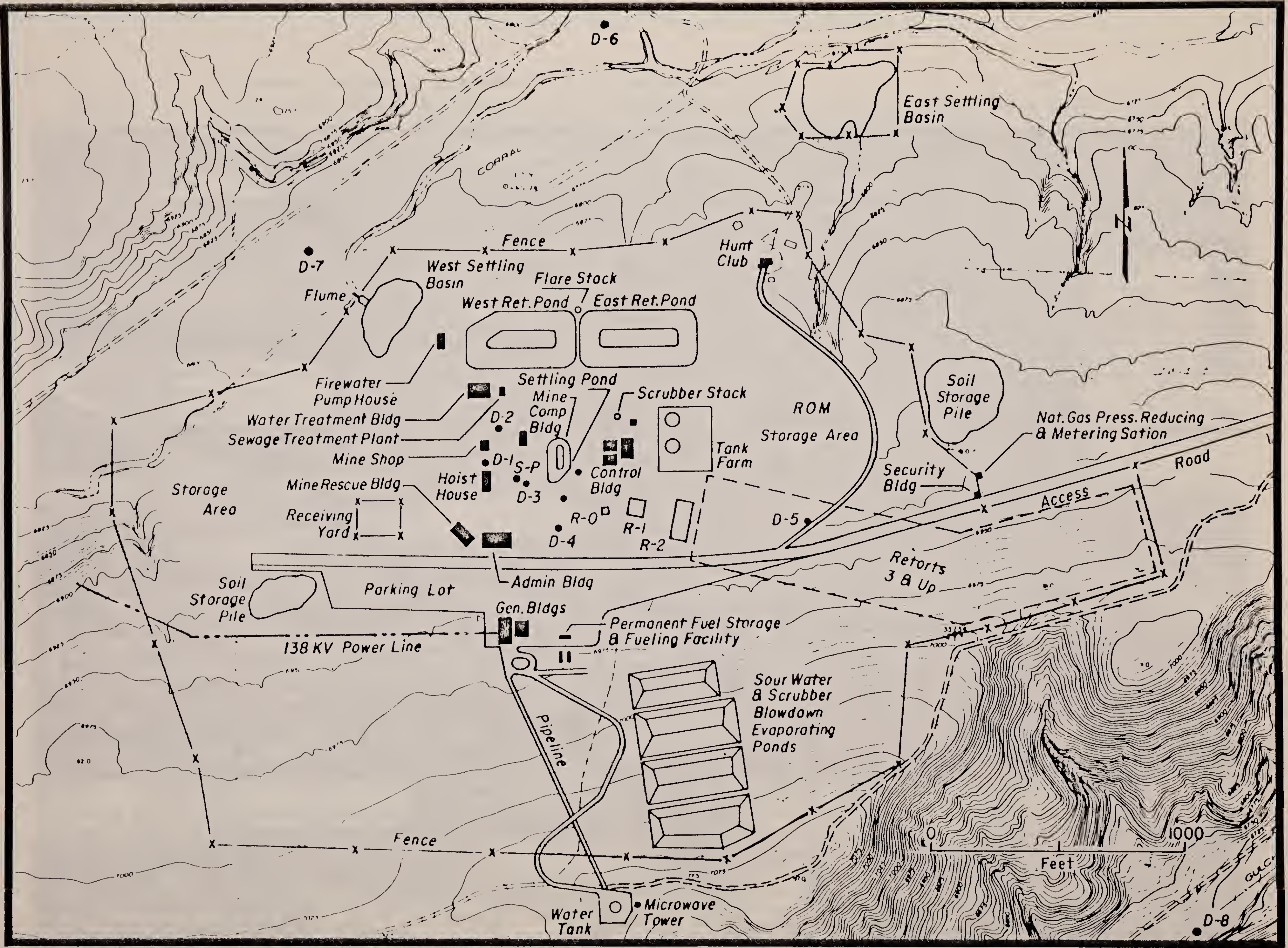


Figure 12. -- Plot diagram of Tract C-a Mine Development Area, and Modular Development Phase retort off-gas treatment and product oil collection facility

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

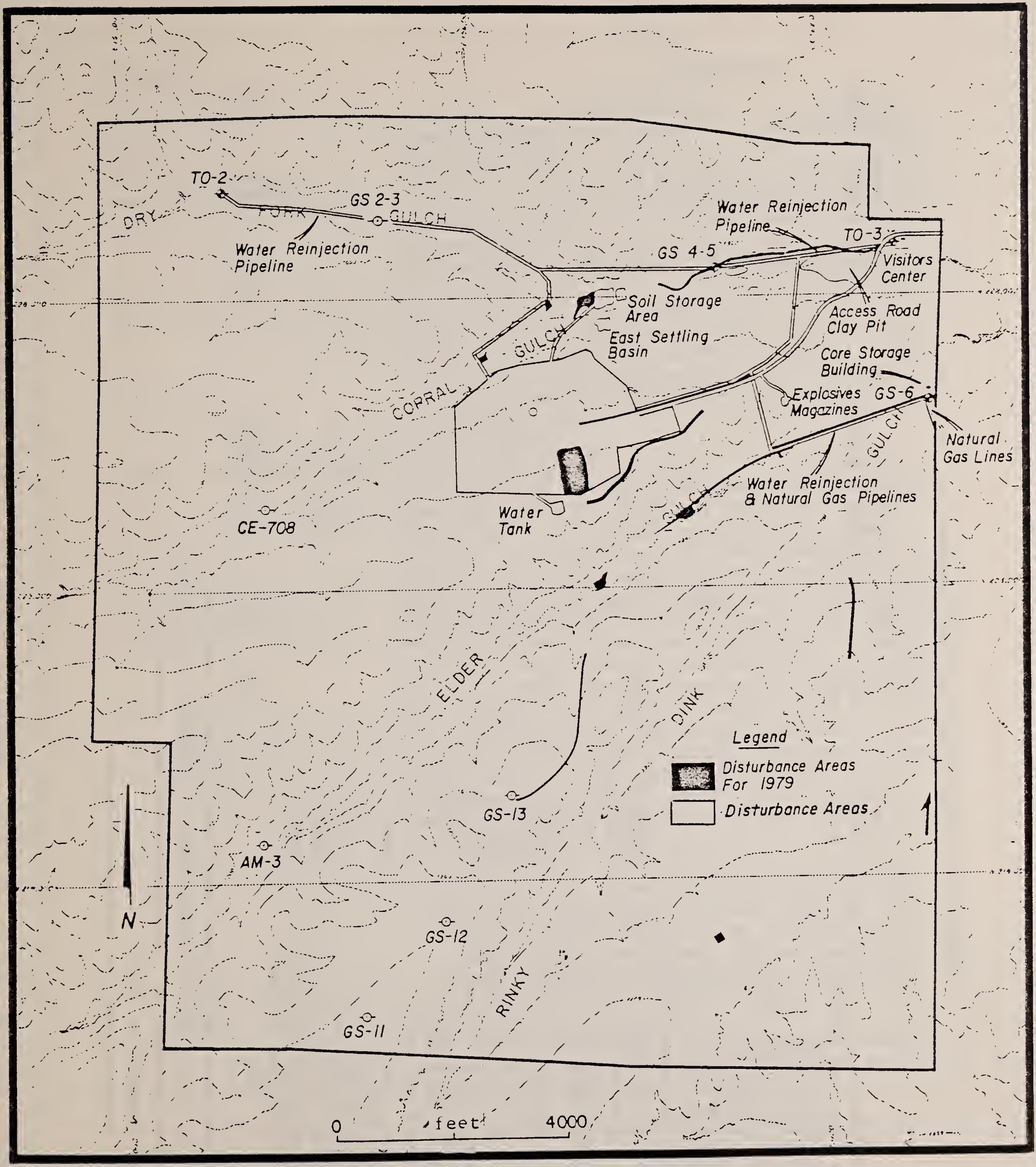


Figure 13. -- Plot diagram showing areas of disturbance on Tract C-a

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

Table 5.-- Acreage disturbed and reclaimed on Tract C-a

Disturbed Area	Disturbance Type	Acreages Disturbed [1]				Acreages Revegetated		
		1977	1978	1979[2]	1980[3]	1978	1979[4]	1979[5]
Mine Service Area Retention Ponds & Plant Site	Major	48.2	3.2					
Retention Ponds						8.0		
Plant Sideslopes						12.0		
Area Near Hunting Club						2.0	1.0	
Area Between Water Tank and Plant Site						5.0		
Diversion System			4.2			3.0	3.0	
Settling Basins			3.4			1.0	1.0	0.1
Equipment Yard						3.0		
Area Near Substation							1.0	
Access/Service Roads	Moderate	10.0	3.0	0.4		6.5	6.5	0.5
ROM Disposal Area	Major		12.3			10.0		
Soil Storage (1,2,3)	Major	4.0				3.0		1.3
Storage A,B,C,D			3.0					
Powder Magazine	Moderate	0.9						
Water Reinjection System	Moderate		12.2	13.8	25.0	7.0		
Transmission Line (on-tract)	Moderate		0.5					
Natural Gas Pipeline (on-tract)	Moderate			0.8				
Reservoirs & Soil Pits	Major				50.0			
Access Road Sand Pit			9.5				5.0	
Hunting Road Clay Pit			4.0	0.9		2.0		
Monitoring Facilities	Moderate		0.2					
Trailer Parking Facility					5.0			
Evaporation Field	Major		7.0					
Scrubber Blowdown Ponds	Major			8.9	10.0			
Scrubber Blowdown Pond Pipeline	Moderate			0.05				
Airplane Ridge Road Relocation	Moderate			1.9				
Old Airplane Ridge Road Segment							8.5	
TOTALS		63.1	62.5	26.75	90.0	62.5	26.0	1.9

[1] Acreages revised from 1978 Annual Report based on "as built" survey data

[2] Includes 8.5 acres disturbed between February 16, 1979, and February 29, 1980

[3] Estimated disturbance for reporting period March 1980 - February 1981

[4] Areas revegetated May 1979

[5] Areas redisturbed during 1979 and reseeded in November 1979

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

Facility	Description
	livestock, and large wildlife from construction areas. Remainder of tract is open to public access and use.
Mine development area	60 acre (24 ha) area on the south side of Corral Gulch was leveled for mine development, MDP retort off-gas treatment plant, shale oil storage, impoundments, and laydown yards (figure 14).
Run-of-mine area	15 acres (6 ha) were cleared east of mine development area for disposal of rock mined from shafts, mine workings, and MDP retorts. Three lysimeters will be installed to collect samples of water seepage through raw shale placed in the disposal area.
Shafts/headframe/hoists	Service/Production (15-foot (4.6 m) diameter): A 95-foot (29 m) high steel headframe was constructed over the Service/Production shaft collar and temporarily equipped for shaft sinking. The headframe is now permanently outfitted for MIS retort development with a 50-ton (45t) ore bin (figure 15). A 400 hp hoist and 500 KVA backup generator set are housed in the adjacent hoist building (Figure 16). The Service/Production shaft was conventionally sunk to design depth of 979 feet (299m) and equipped with guides, 4-ton (3.6t) rock skip, and man cage. The shaft is concrete lined to limit ground water seepage. Mine ventilation intake air is directed down this shaft from a surface-mounted axial fan ducted through a connecting tunnel. Heaters are used to warm the air during cold weather. - 10-foot (3 m) diameter Ventilation/Exhaust shaft was raise bored 971 feet (296 m) from "G" production level to the surface and equipped with a permanent 300 hp surface-mounted exhaust fan assisted by auxiliary fans on each mine level (figure 17). - An additional 10-foot (3 m) diameter raise bored shaft is being raise bored for a secondary service and escape hoist. - Two sub-level 8-foot (2.4 m) diameter ore passes were raise bored from "G" to "E" and "E" to "C" mine levels. - Borehole powerline feeder was drilled from the surface to "G" production level.

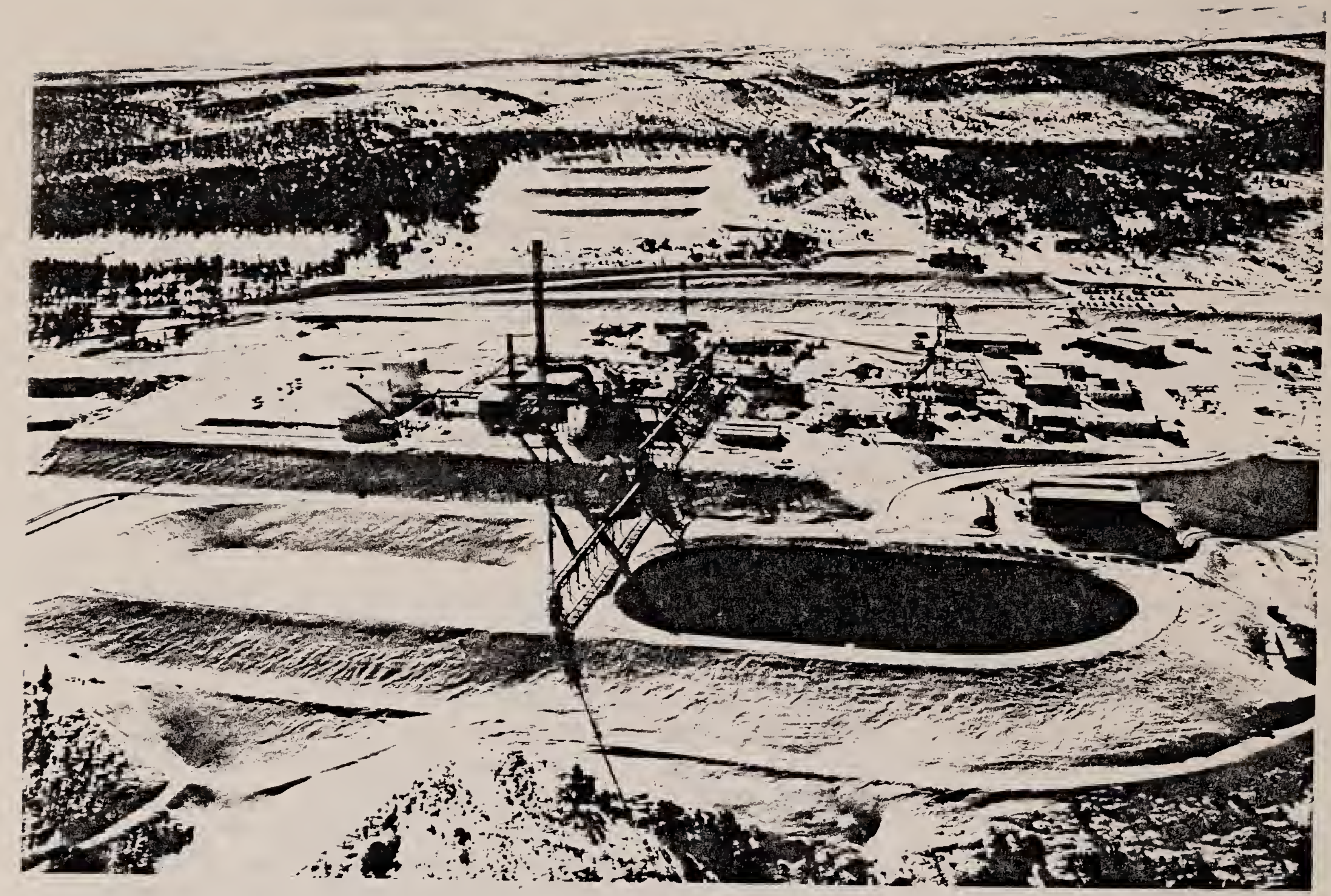


Figure 14.-- Aerial view of Tract C-a taken toward the southwest showing major on-site facilities: (beginning in foreground) two 30-acre-foot ($37 \times 10^3 m^3$) mine water, runoff, and treated effluent settling ponds; retort off-gas flare stack (center foreground); water treatment plant (building above right pond); fire water pump house (far right of ponds); retort off-gas and product oil treatment plant (center, left of flare stack pipeline); steam generator for retorts and process plant (beside short stack); retort off-gas scrubber and incinerator (below tall stack); diked space for existing and future product oil and retort sour water storage tanks (center, left); run-of-mine material disposal area (far center, left); and four 25-acre-foot ($31 \times 10^3 m^3$) scrubber blowdown and retort sour water evaporation ponds (empty basins on hillside above plant area). All process facilities will be used only for initial or Modular Development Phase retorts and will be subsequently replaced with commercial scale units. Right of flare stack pipeline are various mine related structures including: 10 foot (3 m) diameter Ventilation Exhaust shaft fan; 15 foot (4.6 m) diameter Service/Production shaft headframe; office, changehouse, and warehouse buildings; and equipment laydown yard (extreme center, right). Building directly above headframe houses powerline substation and emergency generator.

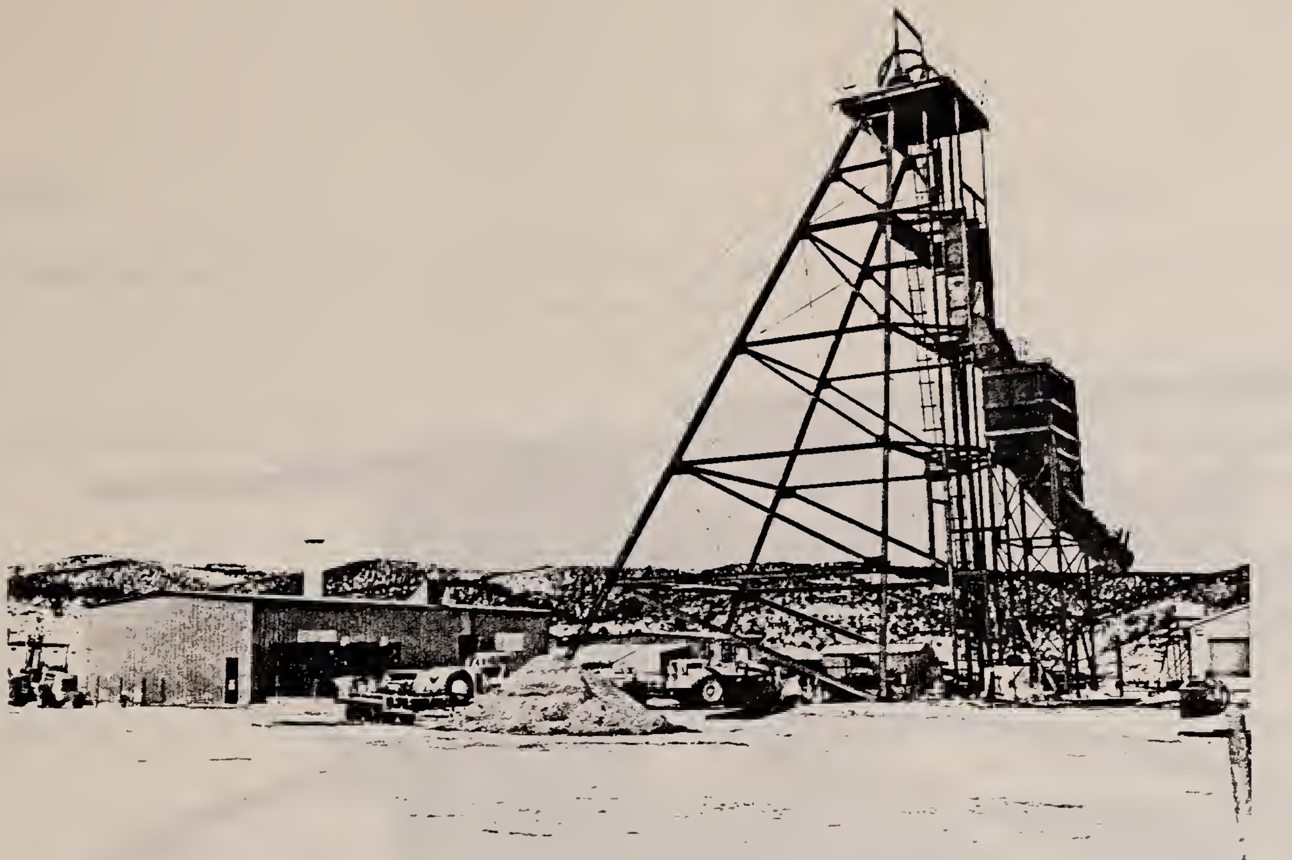


Figure 15. -- Photograph showing 95-foot (29 m) high steel headframe constructed over the 15-foot (4.6 m) diameter, 970-foot (277 m) deep Service/Production shaft on Tract C-a. Skip dump and 50-ton (45t) ore bin are mounted on right side of headframe. A 400 hp hoist and backup generator are housed in the building left of headframe. The shaft is completed, concrete lined to limit ground water seepage, and equipped with ventilation intake heaters at base of headframe to temper air during winter weather. More than 2,000 feet (610 m) of mine production level have been driven from shaft bottom eastward toward sites of Modular Development Phase modified in-situ retorts.

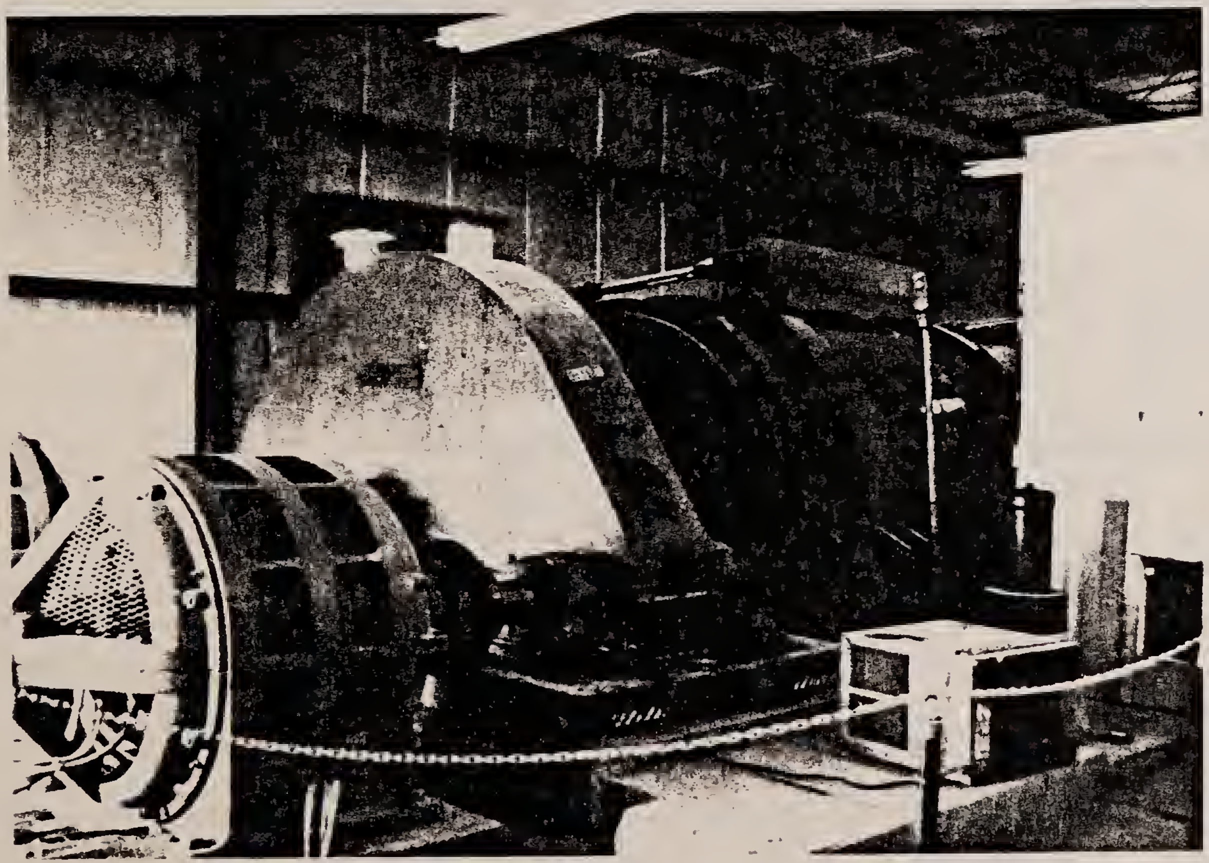


Figure 16. -- Photograph showing 400-hp hoist located adjacent to 15-foot (4.6 m) diameter Service/Production shaft headframe on Tract C-a. Hoist is used for raising muck removed during shaft sinking and mine-level development. These facilities will be used as part of the permanent hoisting works during commercial operations.

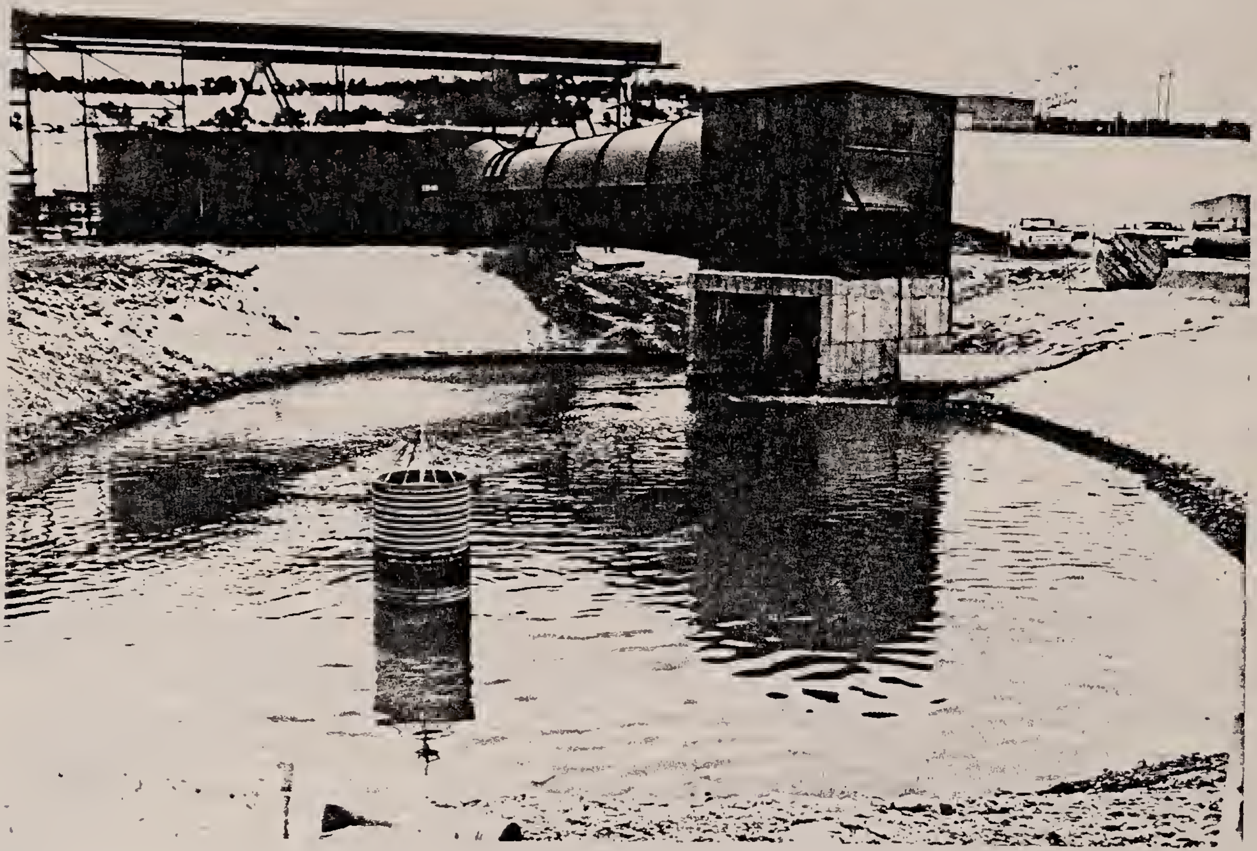


Figure 17. -- Photograph of mine ventilation exhaust fan and horn atop 10-foot (3 m) diameter Ventilation shaft on Tract C-a. Basin is used for collection of surface drainage from shaft service area.

Facility	Description
Mine development	Approximately 46,000 tons (4 x 10^4t) of rock were mined from shafts and nearly 2,000 feet (610 m) of lateral development by year end 1979.
Mine dewatering	Five dewatering wells were drilled and operated with submersible pumps. Only one well was in operation by year end due to drawdown by lower mine workings. Two of four additional dewatering wells have been drilled. One bank of permanent mine pumps was installed on "G" level.
Reinjection	Four reinjection wells were drilled east and west of the mine development area for direct disposal of up to 1,500 gpm (95 dm^3/s) of water from mine seepage and dewatering wells. Reinjection system has a pumping capacity of 3,000 gpm (189 dm^3/s).
Retort "0"	Several blast holes were drilled for rubblizing the first MDP retort. When completed, this retort will be approximately 30'x30'x170' (9 x 9 x 52 m) high extending from the top of the R-5 to the base of the R-6 zones (Figure 18).
Major tankage	Tankage installed on-tract consists of: - 5,000 gallons (19 x 10^3L) gasoline and 15,000 gallons (57 x 10^3L) diesel at Parking Bench fueling island. - 20,000 gallons (76 x 10^3L) diesel and 20,000 gallons (76 x 10^3L) gasoline at Generator Building. - Two 10,000 gallons (38 x 10^3L) diesel fuel tanks one for gravity fed to mine levels and the other for mine service air compressors. - 9,000 gallons (34 x 10^3L) gasoline tankage at shaft sinking contractor's area. - 20,000 bbl. (3,180 m^3) retort product oil storage tank east of retort gas treatment plant. - 20,000 bbl. (3,180 m^3) retort sour water storage tank east of retort gas treatment plant. - 500,000 gallons (19 x 10^7L) mine water seepage and fire water storage tank on ridge south of mine development area.

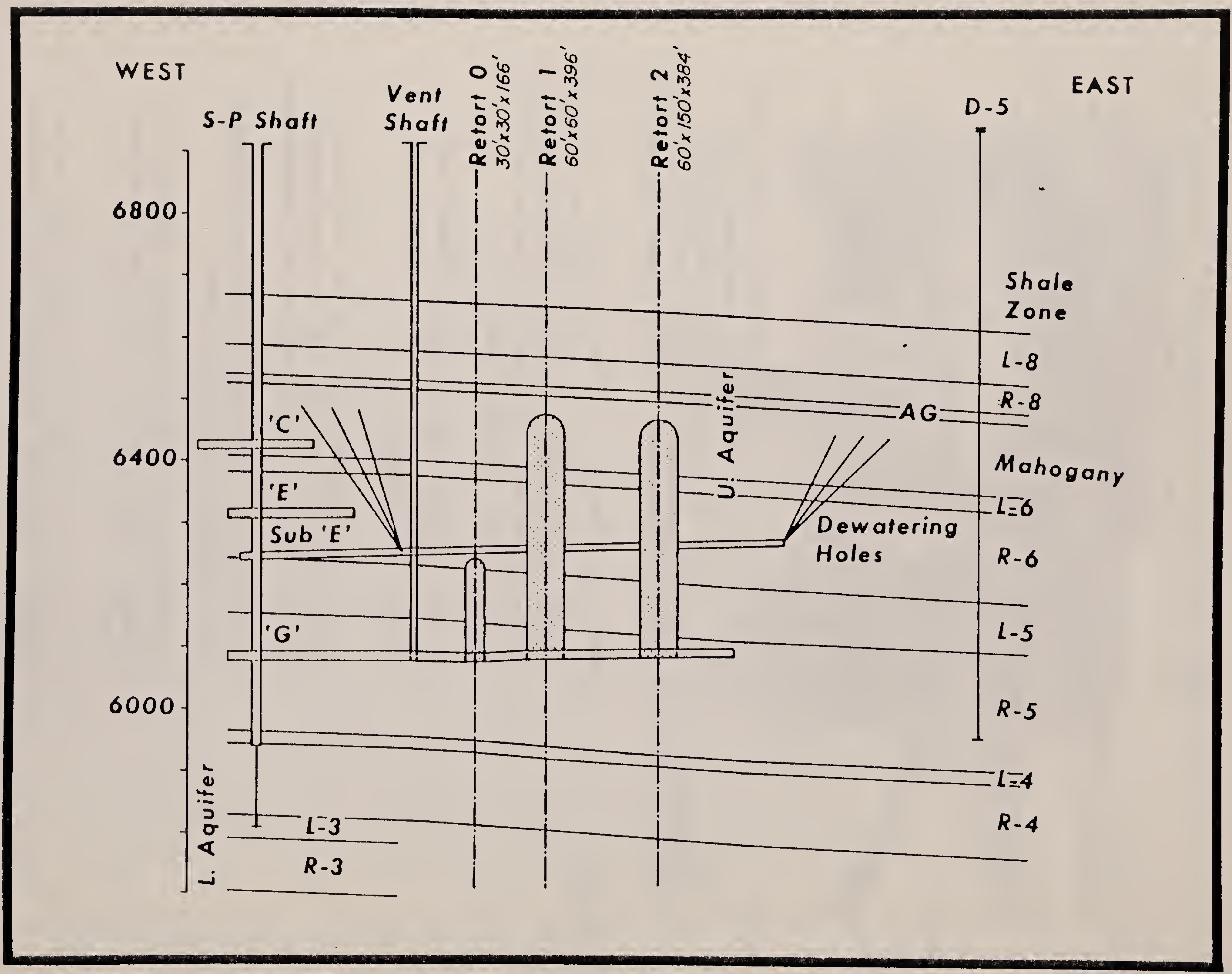


Figure 18.-- Diagrammatic cross section of Tract C-a, showing Modular Development Phase retort size and stratigraphic relation

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

Fuel use	During 1979, 176,535 gallons (6.7×10^5 L) of gasoline, and 228,164 gallons (8.6×10^5 L) of diesel were consummed on-tract.
Impoundments	Major impoundments constructed on-tract include: - Two, 30-acre-foot ($37 \times 10^3 m^3$) retention ponds for mine seepage, dewatering well water, and construction area runoff sediment settling, and treated sewage and process water. - Two Mine Development Area runoff collection and evaporation ponds with collector ditches designed to handle 100-year storm event. - Four nearly 7 acre-foot each ($3.2 \times 10^4 m^3$) plastic lined retort off-gas scrubber blowdown and sour water retention and evaporation ponds. - Two small headframe ponds for primary settling of solids in mine seepage water.
Building and plants	Building and plants constructed on-tract include: - Generator Building: houses a 2,500 KW standby generator, and main transformers and distribution switching for power supplied to the tract over the 138 KVA line. - Water Treatment: multi-media filtration for mine seepage water, 25,000 gpd (1 dm^3/s) reverse osmosis potable water treatment, and 14,000 gpd (.6 dm^3/s) extended aeration sewage treatment plant. Potable water plant not currently being used due to high suspended solids and H_2S contamination of feed water. - Administrative: 4,500 square foot (418 m^2) steel span building housing lessee and contractor on-site engineering and management staff (Figure 19), and three office trailers. - Warehouse: 1,600 square foot (427 m^2) of general purpose warehouse and additional office space. - Mine Rescue: 4,600 square feet (427 m^2) utility building used for safety personnel, contractor quality control, emergency equipment shelter, and maintenance. - Fire Water Pump: 1,000 square foot (93 m^2) shelter for fire water pumps.

	- Shops: 1,500 square feet (139 m^2) of general purpose shop space. - Compressor: 1,860 square feet (173 m^2) of shelter for mine air compressors and dewatering well switch gear. - Core Storage: 1,200 square foot (111 m^2) core sample storage shed. - Process Plant: 60,000 square foot (5,574 m^2) open work MDP retort off-gas scrubbing and oil storage facilties including 120 psi (8.4 kg/cm^2) steam generator for retort and plant operations, water treatment, motor and process control center, and oil/water knockout (Figures 20 and 21). - Flare: 165-foot (50 m) high retort off-gas upset flare stack (see section on Processing). - Explosive Storage: one-half acre (.2 ha) bermed area for three portable explosive magazines.
Clay borrow area	Five-acre (2 ha) clay borrow pit currently excavated to a depth of 20 feet (6 m).
Airstrip	5,000-foot (1,525 m) long, 50 foot (15 m) wide, dirt airstrip on 84 Mesa five miles (8 km) northeast of tract suitable for service by general class twin-engine aircraft.

Tract C-b

Development Scheme

Tract C-b is under lease to the Cathedral Bluffs Shale Oil Company (Occidental Oil Shale, Inc. — operator; Tenneco Oil Company —partner). Approved DDP's call for development of the tract by MIS methods from deep multi-level mine workings accessed by large diameter shafts through better than 1,000 feet (305 m) of overburden (Figures 22 and 23). Originally the lessees had planned to develop the lease by direct underground mining of the rich oil shale within a zone less than 100 feet (30 m) thick and surface retorting. Unforeseen problems of rock strength, and complex jointing and fracturing, however, would have resulted in unacceptably low resource recovery. When Occidental Oil Shale, Inc., became lease operator, they felt the rock mechanics and resource recovery problems could be solved and the tract brought to commercial operation with MIS technology developed at their private Logan Wash site near the southern edge of the Piceance basin.

As a result, three, nearly 2,000-foot (610 m) deep commercial size shafts are being sunk on-tract. Commercial scale hoist tower super structures

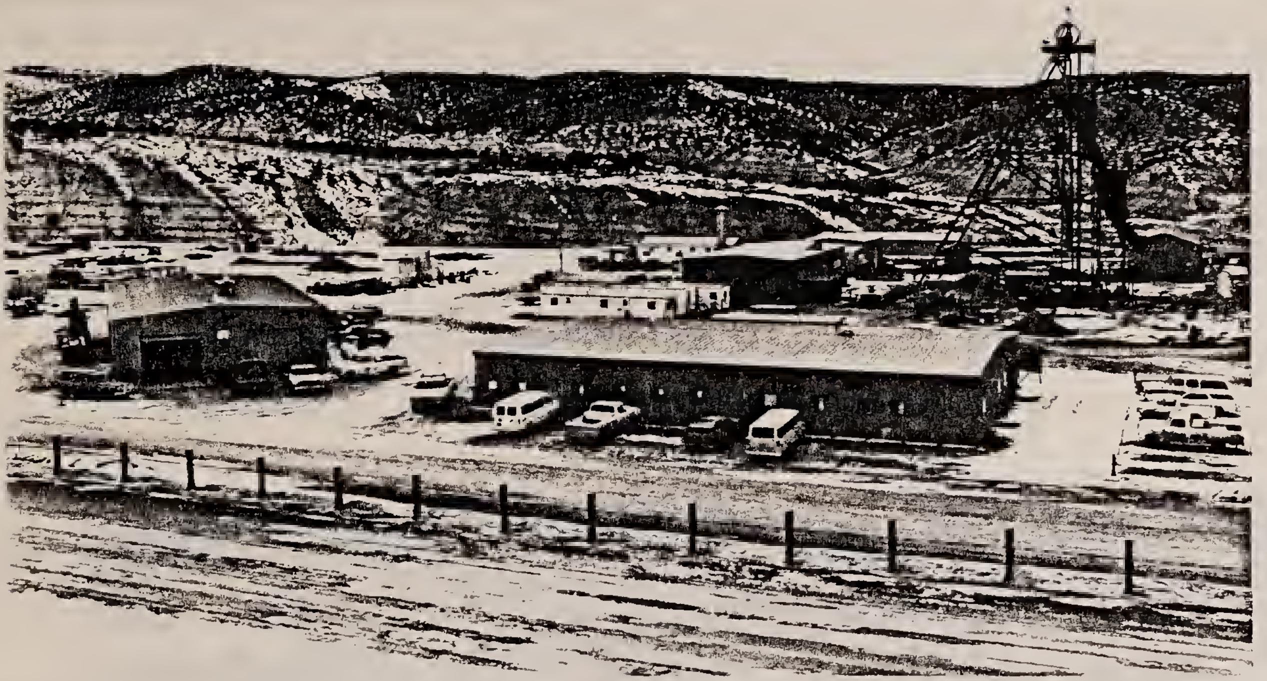


Figure 19. — Photograph taken toward northeast showing Tract C-a mine support facilities, including mine safety and emergency equipment shelter (center, left), office and administration building (center), and Service/ Production Shaft head frame and hoist house (upper, right). Corral Gulch is the drainage just beyond these facilities.

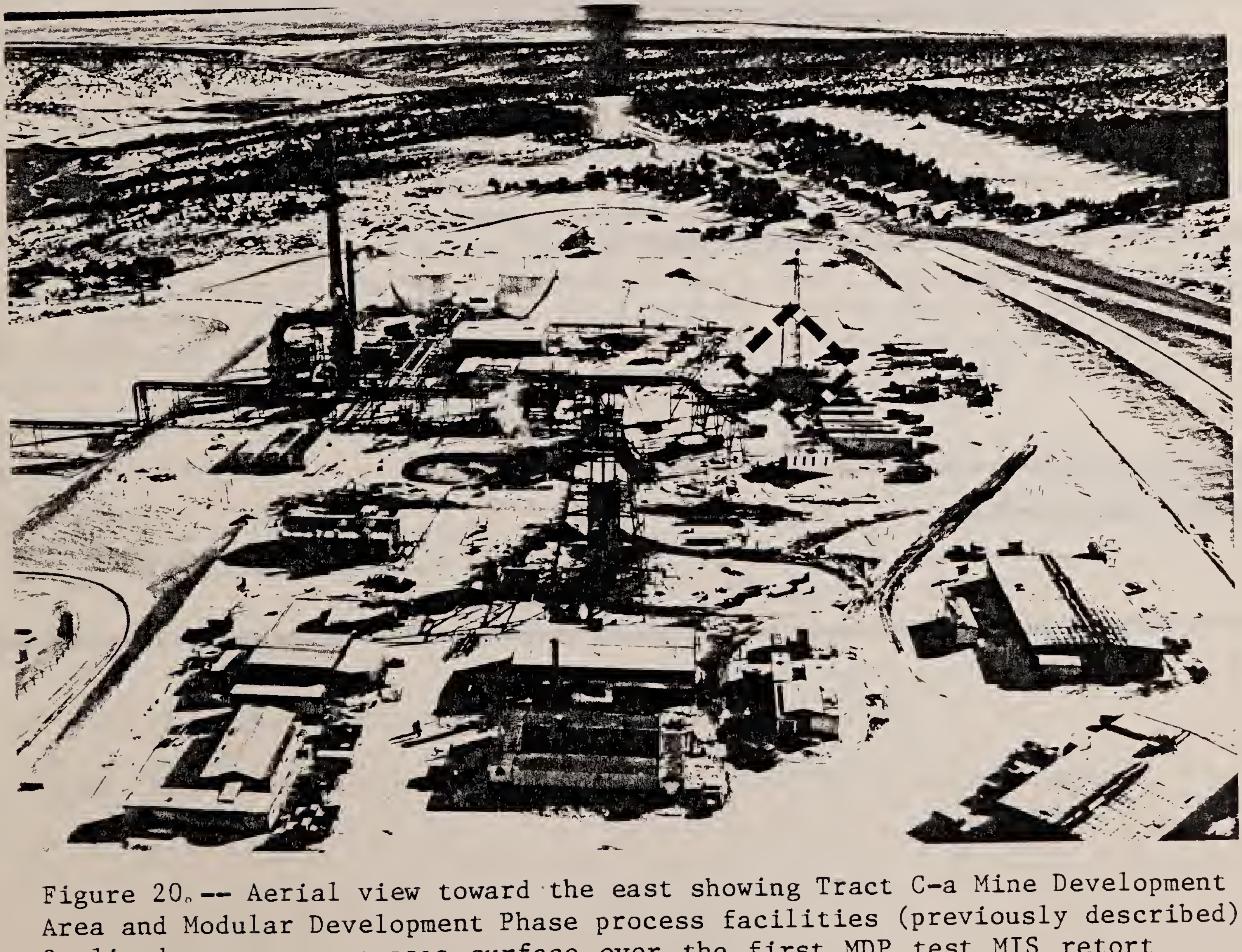


Figure 20. -- Aerial view toward the east showing Tract C-a Mine Development Area and Modular Development Phase process facilities (previously described). Outlined area encompasses surface over the first MDP test MIS retort where drill rig is coring blast holes.

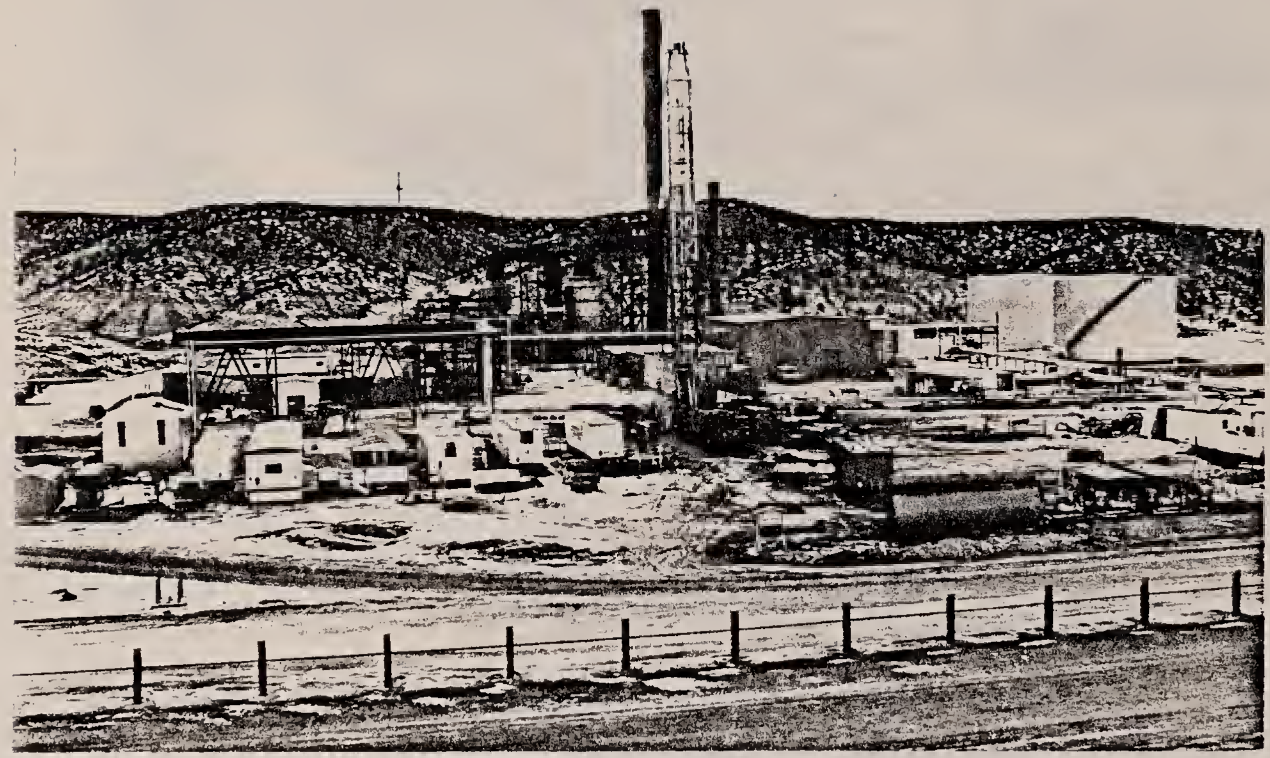


Figure 21. -- Photograph showing Tract C-a Modular Development Phase retort off-gas treatment and product oil collection facility. This plant will further separate retort product oil/gas/water, provide steam to regulate in-situ retort temperature (short stack), incinerate retort off-gas and scrub out sulfur gases before venting to atmosphere (large stack), or flare the off-gas stream during retort start-up and upset conditions (thin stack, left rear). Tanks will be used to store retort product oil and sour water. Drilling rig is boring holes for placement of explosives to rubblize initial MDP retort and for subsequent injection of air and steam to sustain and control the retorting process.

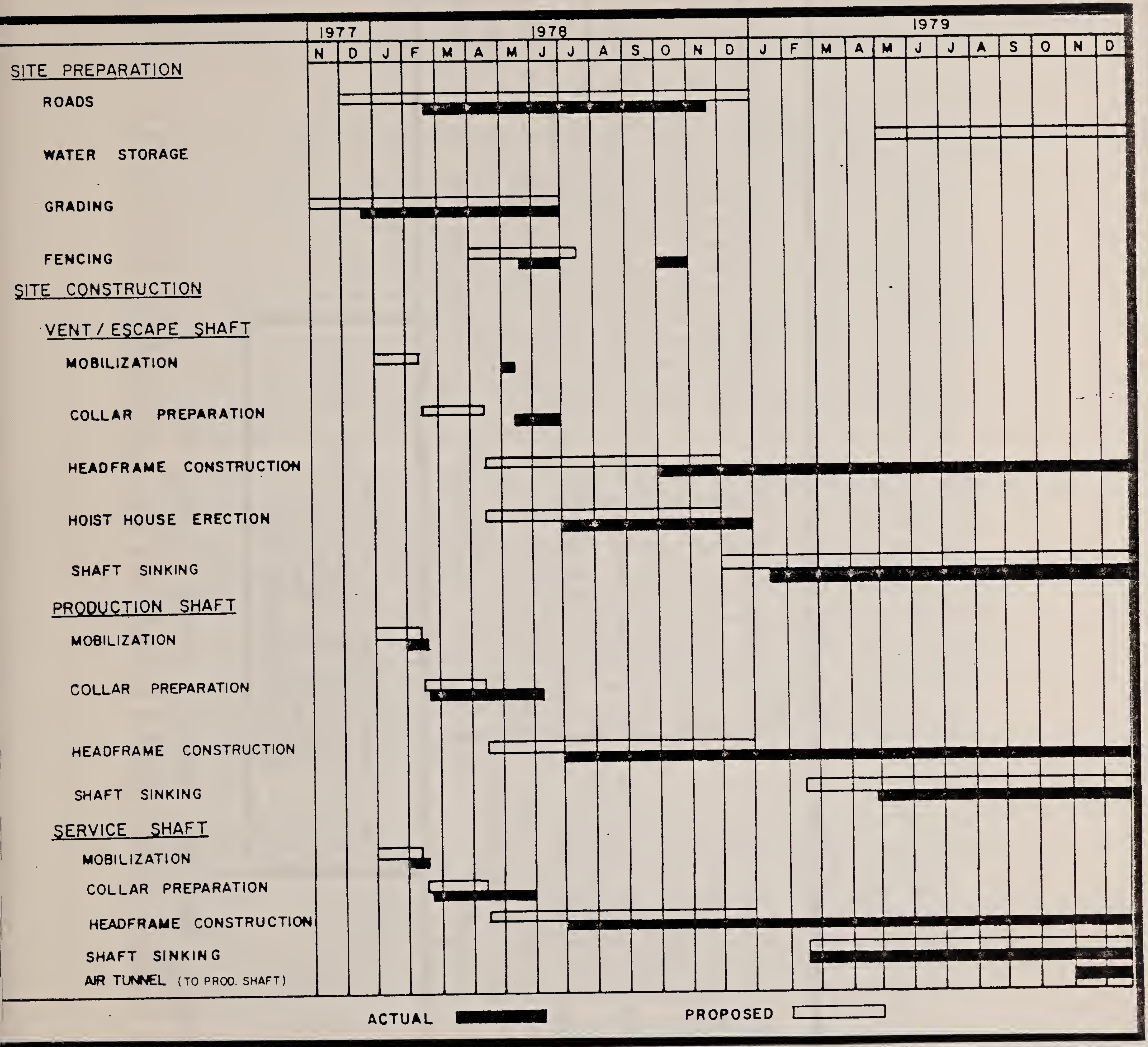
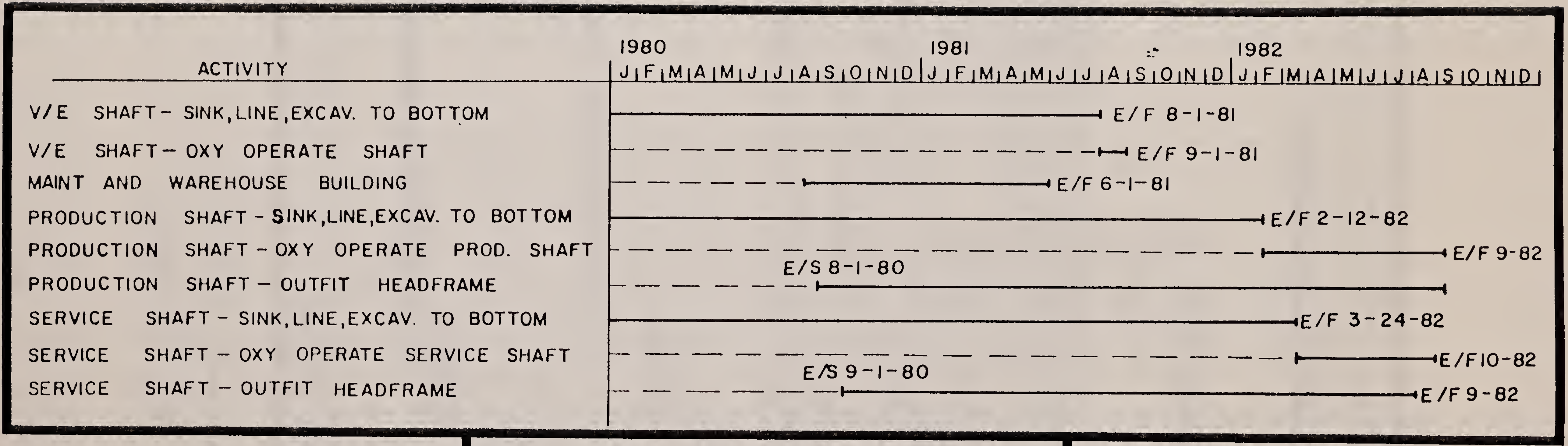


Figure 22.-- Achieved development schedule for Tract C-b

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.



ALL SINKING RATES AT 40 ft/wk
ALL GROUT CYCLES ASSUMED TO BE 60 DAYS
E/S = ESTIMATED TO START
E/F = ESTIMATED TO FINISH
V/E = VENTILATION/ESCAPE SHAFT

Figure 23. -- Near-term construction schedule for Tract C-b

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

and headframes are inplace and temporarily equipped for shaft sinking and initial mine level station development. A fourth shaft for commercial retort off-gas exhaust to surface treatment facilities is scheduled for start of excavation in late 1980.

Approved DDP's call for development of MIS retorts from multiple mine levels (much like widely spaced floors in a tall building) because the overburden is too deep to practicably drill retort rubblizing blast holes from the surface. Instead, the intervening oil shale (floor and ceiling) will be drilled with blast holes from several mine levels. Mine level dimensions will be designed to take out approximately 20 percent of the rock volume within each MIS retort chamber. Mined oil shale will be hoisted in the Production shaft and deposited on the surface in a manner that permits future excavation for possible above ground retorting. Blast holes will be detonated essentially simultaneously rubblizing the unmined shale and distributing the mine void space throughout the bulk filled retort chamber. Boreholes will then be extended into each MIS chamber from an overlying mine air level. Igniters will be lowered into each chamber, and air and steam supplied through the boreholes to sustain and control the retorting process.

Shale oil production will increase rapidly from 2,500 bbl/day (398 m^3/day) by 1984 to commercial output of 57,000 bbl/day (906 m^3/day) by the late 1980's. Individual MIS retorts will be approximately 200 by 200 feet (60 x 60 m) at the base and 310 feet (95 m) high. Retorts will be operated in clusters of eight or more to achieve desired rate of production. At commercial output, 45,000 to 50,000 tons (40,800 to 45,350 t) of oil shale will be mined daily from the several mine levels and retort chambers over the anticipated tract operating life of 56 years. There is a possibility that the richer mined shale will be surface retorted. This would increase estimated resource recovery from 1.2 billion to 1.65 billion barrels ($1.9 \times 10^8 m^3$ to $2.6 \times 10^8 m^3$), or as much as 55 percent of the shale oil resource across the breadth of the 300 foot (92 m) thick zone. An artist's concept drawing of subsurface development is depicted in figure 24.

Development work during 1979 was devoted primarily to shaft sinking and excavation of mine level stations. In 1980, shaft sinking and mine level development will continue. Construction will also start on permanent warehouse and employee service buildings. The lessee will also make initial use of a sprinkler irrigation system and a test reinjection well for disposal of excess ground water pumped from mine workings. In addition, some of the mine water will be treated and released to natural surface drainages, as was done with virtually all mine drainage during 1979.

Major Facilities

The following list summarizes the major surface and mine facilities constructed through 1979 on Tract C-b as pictured in figure 25 with plot relationship shown in figures 26, 27, 28, and 29.

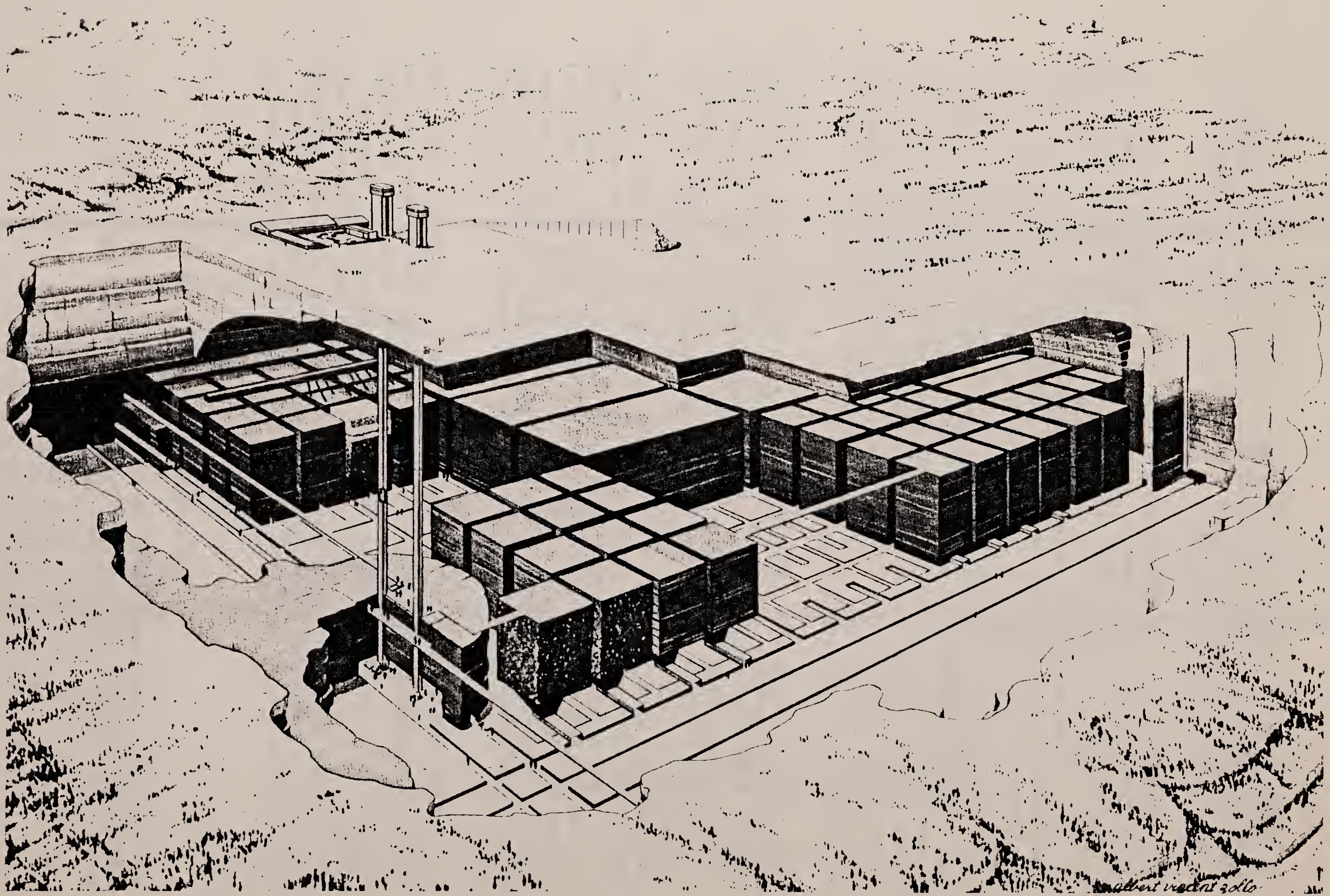


Figure 24. -- Concept drawing of multiple-mine-level development of modified in-situ retorts beneath Tract C-b

From: Cathedral Bluffs Shale Oil Company, 1978.

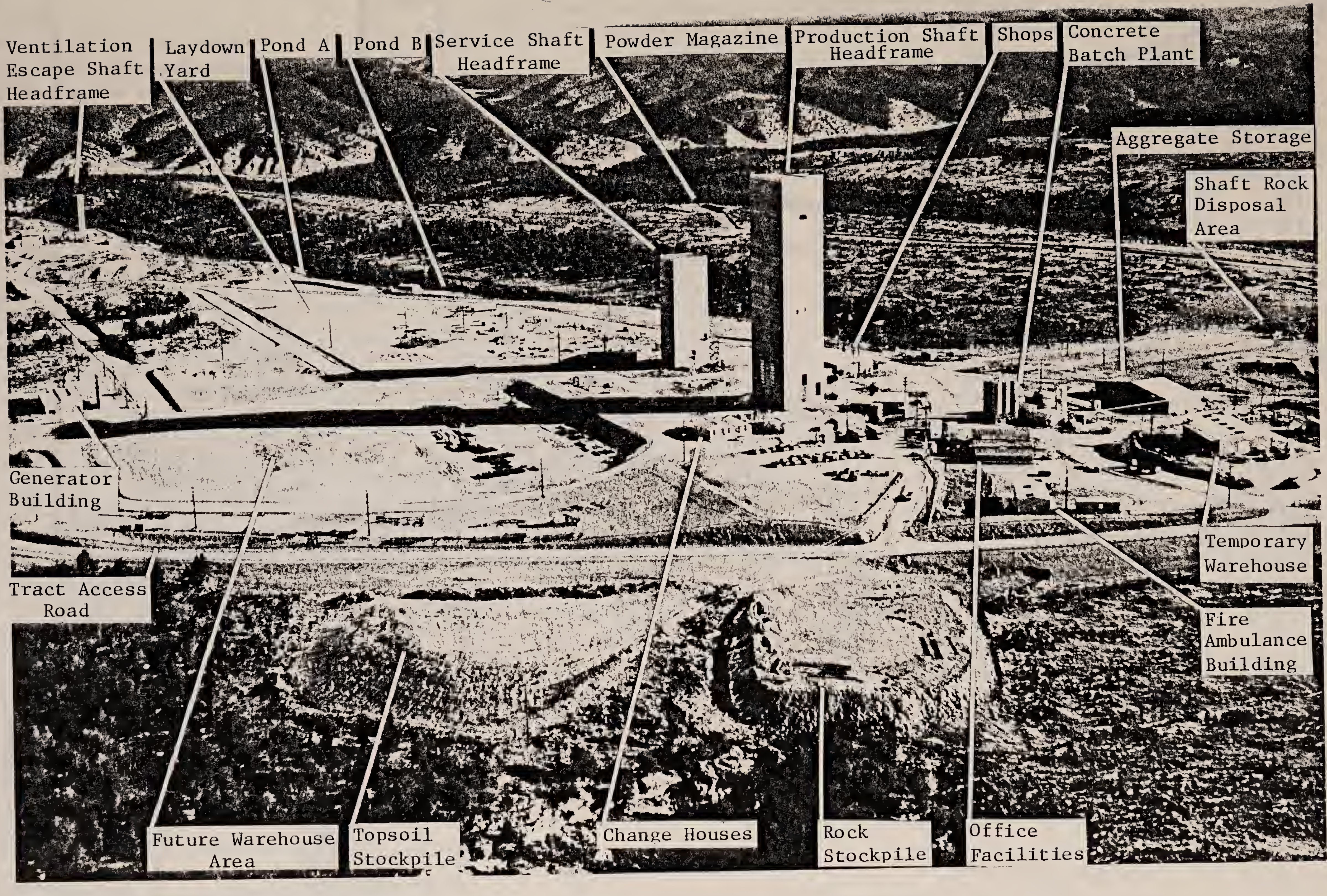


Figure 25.-- Aerial view of Tract C-b toward northeast showing major Mine Development Area on-site facilities

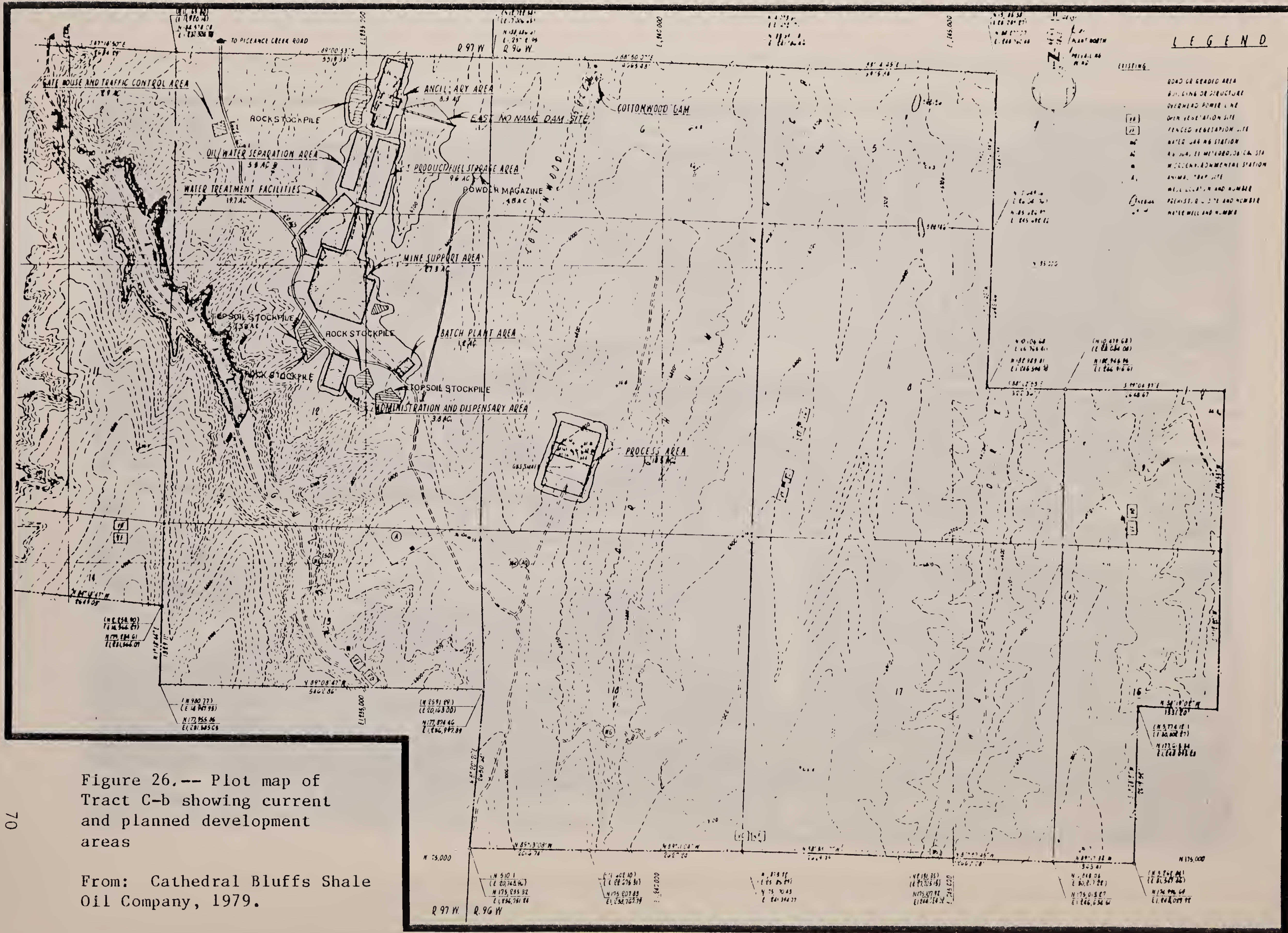


Figure 26.-- Plot map of Tract C-b showing current and planned development areas

From: Cathedral Bluffs Shale Oil Company, 1979.

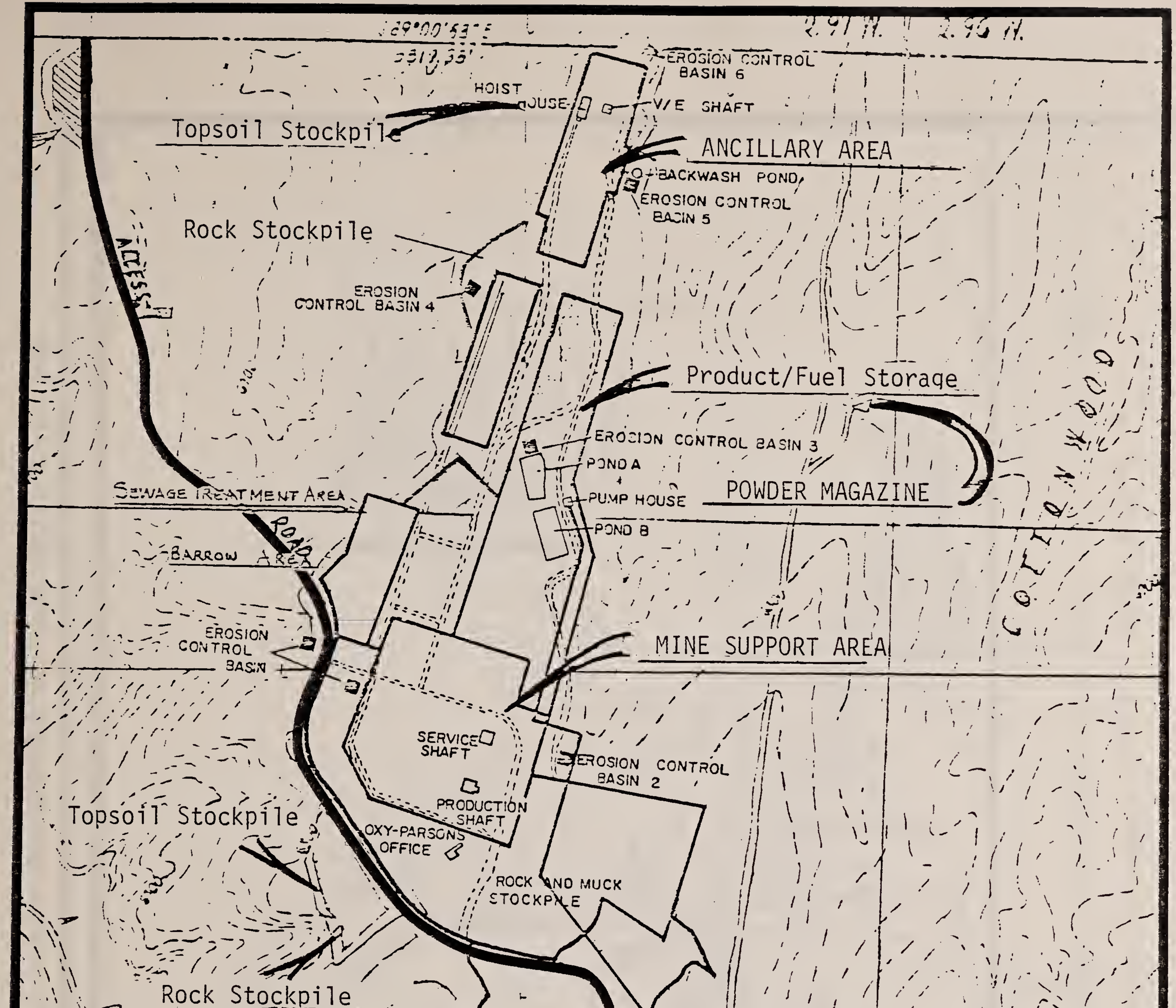


Figure 27. -- Plot diagram of existing facilities on Tract C-b

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

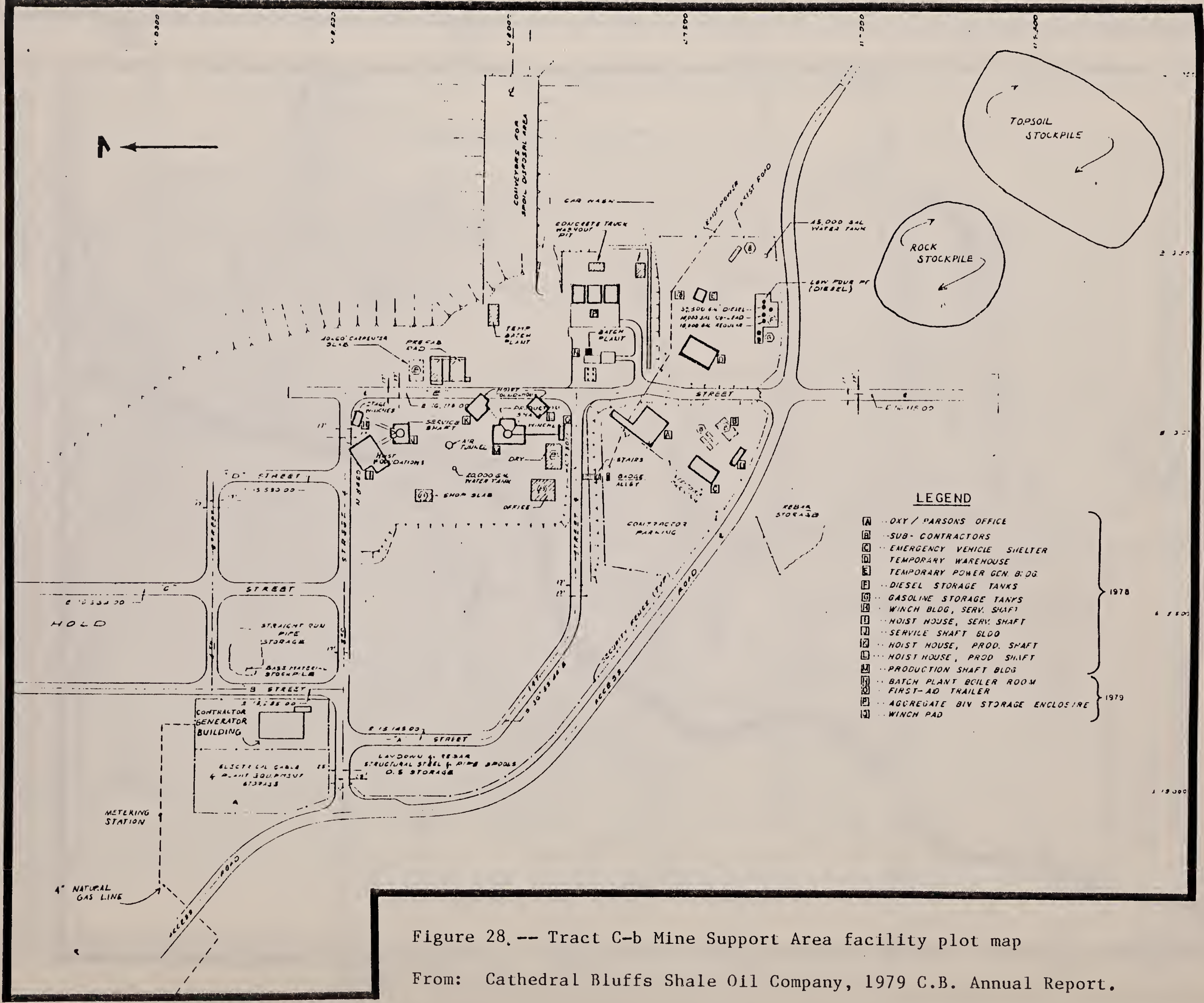


Figure 28. -- Tract C-b Mine Support Area facility plot map

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

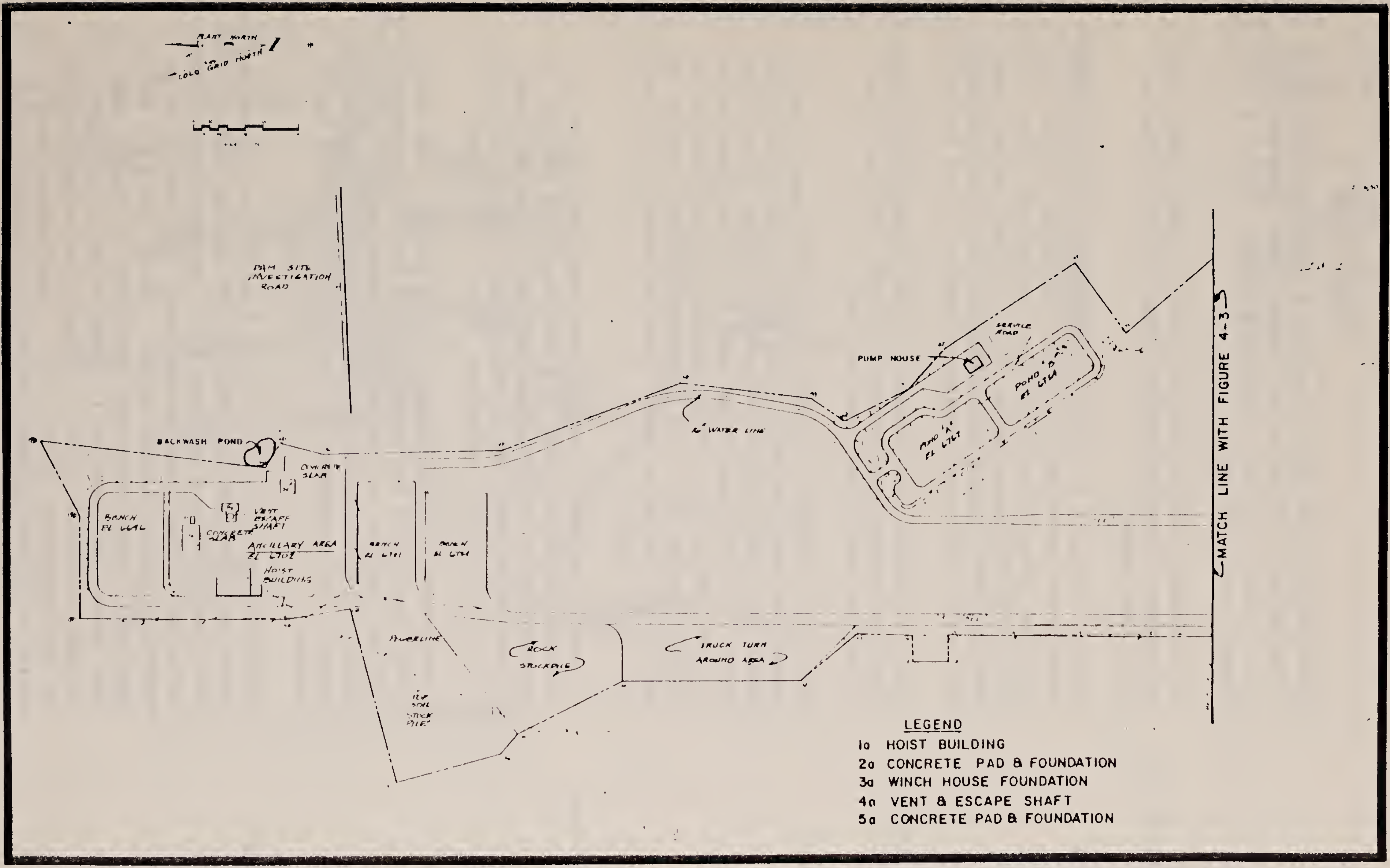


Figure 29. -- Tract C-b Ancillary Area facility plot map

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

Facility	Description
Access	Three miles (4.8 km) of two-lane paved private land crossing and BLM dedicated access from Piceance Creek Road (Rifle - 40 miles (64 km), Meeker - 40 (64 km), Rangely - 65 (105 km)).
Employee transportation	Approximately 80 percent of on-tract employees ride in company operated busses from parking areas in Rifle and Meeker.
Earthwork	Better than half a million cubic yards ($4 \times 10^5 m^3$) of earth were excavated to level 121 acres (49 ha) for the Mine Support and Ancillary facilities. From this area, 285,000 cubic yards ($2.9 \times 10^5 m^3$) of soil and sub-soil were bladed and stockpiled in four locations for use in future reclamation (Figure 31 and Table 5).
Natural gas line	Tract is served by a 4-inch (10 cm) natural gas pipeline for power generation for shaft sinking, construction, and other on-site uses.
Powerline	Tract is currently served by a 7.2 KVA rural electric powerline used for office and monitoring facilities. Power for construction and shaft sinking is provided by two on-site generating plants with a tie over to offices and shops. These plants will be reduced to standby status by a 138 KVA transmission line to be built from the White River Electric Association switch yard near Meeker.
Communications	A rural telephone line has been replaced by an 11-channel microwave link to Grand Junction feeding an on-tract PBX. Field communication is accomplished by mobile radios. Construction has started on laying a 10-line buried telephone cable from Meeker.
Security	Access road guard building, roving patrol, and nearly 5,000 feet (1500 m) of chain link fence are used to control traffic to development areas and to limit public, livestock, and wildlife access to construction areas. The remainder of the tract is open to public access.
Water supply	Potable water is trucked daily from Rifle. Construction water is taken from either a 20,000 gallon (7.6×10^4 L) tank (supplied by a shallow well) at the Piceance Creek crossing of the tract access road, or from the mine water storage/treatment ponds. Two 60 gpm ($3.8 dm^3/s$) deep well pumps have been installed to supply pump seal water and eventually potable water through a package treatment plant. Tankage for water storage is strategically located at: Ventilation/Escape shaft - 10,000 gallons (38,000 L); concrete batch

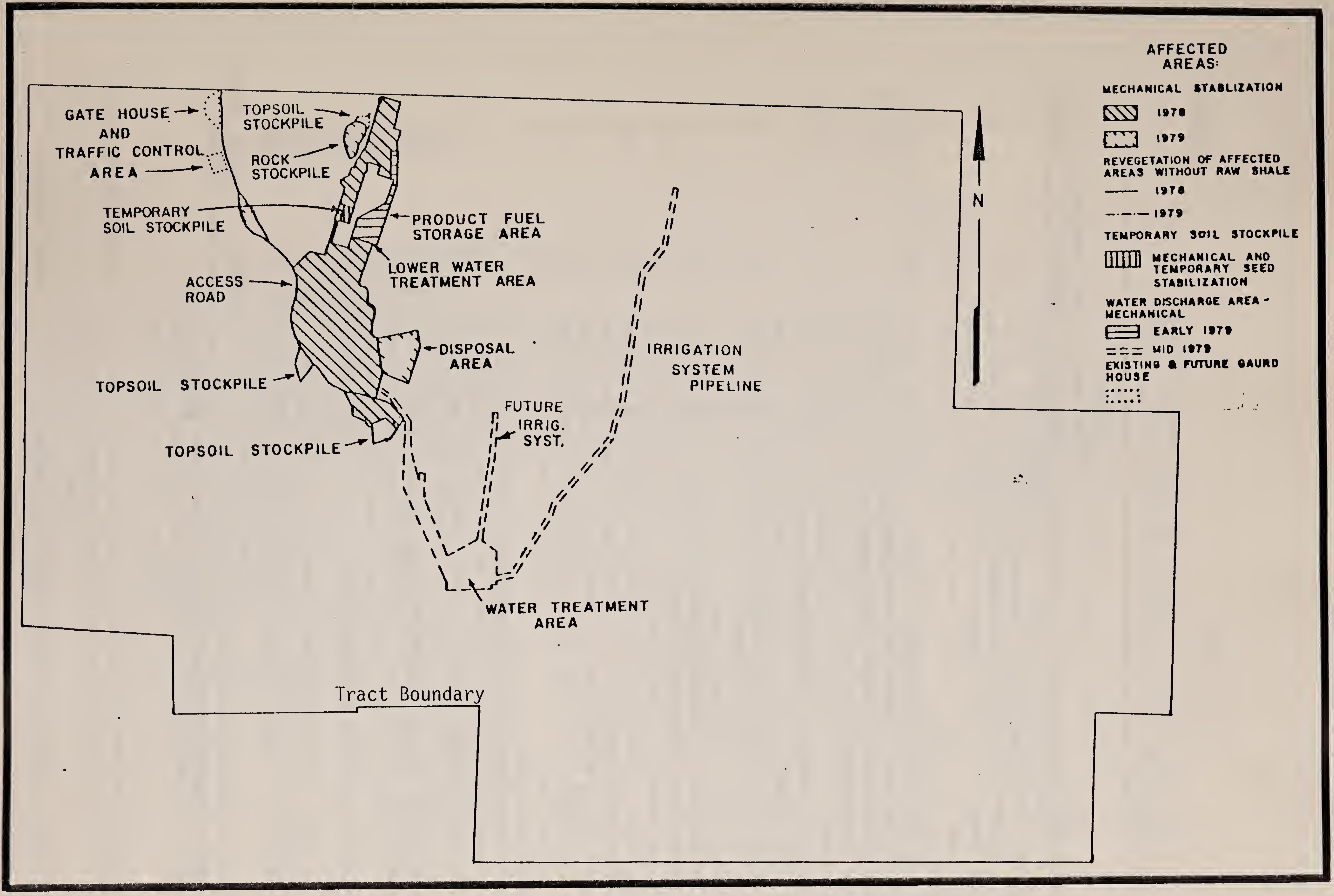

GATE HOUSE AND TRAFFIC CONTROL AREA
TOPSOIL STOCKPILE
ROCK STOCKPILE
TEMPORARY SOIL STOCKPILE
PRODUCT FUEL STORAGE AREA
LOWER WATER TREATMENT AREA
ACCESS ROAD
DISPOSAL AREA
TOPSOIL STOCKPILE
TOPSOIL STOCKPILE
IRRIGATION SYSTEM PIPELINE
FUTURE IRRIG. SYST.
WATER TREATMENT AREA
Tract Boundary
N
AFFECTED AREAS:
MECHANICAL STABLIZATION
1978
1979
REVEGETATION OF AFFECTED AREAS WITHOUT RAW SHALE
1978
1979
TEMPORARY SOIL STOCKPILE
MECHANICAL AND TEMPORARY SEED STABILIZATION
WATER DISCHARGE AREA - MECHANICAL
EARLY 1979
MID 1979
EXISTING & FUTURE GAURD HOUSE

Figure 30 -- Plot diagram of disturbed and reclaimed areas on Tract C-b

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

Table 6.-- Acreage disturbed and reclaimed on Tract C-b.

Affected Areas	(1978=1) Disturbance Timetable	Reclamation Phase-Years	Acreage
Existing Guard House	1	61	1
Traffic Control Station & Future Guard House Area	1	61	3
Access Road	1	61	12
Abandoned Access Road	1	1	10
Mine Support & V/E Shaft Area (Administration, stockpiled rock areas, batch plant, sedimentation impoundments, water treatment)	1	61	101
Barrow Area (Acreage included with Mine Support and Ancillary Area)	2	2	3*
Stockpiled Rock - V/E Shaft Area	2	61	3*
Stockpiled Soil - Support Area	1	1	5
Stockpiled Soil - V/E Shaft Area	1	2	1
East No Name Dam - Investigation	1	2	1
East No Name Dam - Potential Site	3	61	40
Explosives Area	1	61	1
Process Area	3	61	20
Temporary Soil Stockpile	2	2	3*
Product Storage Area	3	61	9
Water Discharge	2	61	26
Land Application	2	2	4
Disposal Embankment Initial Berm into East No Name Gulch	1	4	1
Fill into East No Name	2-3	4	5
Berm across Cottonwood Gulch	3-4	5-6	53
	5-6	6-7	105
Advancing Face in Cottonwood & Sorghum and Starter Berms	7-10	8-11	151
	11-15	12-16	118
	16-29	17-30	339
Advancing Face across Sorghum Gulch	30-35	31-36	169
	36-40	37-41	271
	41-50	42-51	231
	51-60	52-62	212
		TOTAL	1,898 Acres

*Included in the Mine Support and V/E Shaft area acreage (101)

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

Facility	Description
	plant - 45,000 gallons (171,000 L); receiving yard - 45,000 gallons; Pond C - 45,000 gallons; and service and production shaft area - 20,000 gallons (76,000 L).
Run-of-mine area	Approximately 77,300 cubic yards (2,200 m^3) of rock have been mined during shaft sinking and station development through 1979. Most of this rock has been placed in a prepared permanent disposal area east of the Production shaft (Figure 26 and 27), or used to create small lay down and storage yards. To date, six acres (2.4 ha) have been used for this purpose.
Shafts/headframes/ hoists	Production Shaft - 29-foot (8.8 m) diameter: A 313-foot (95 m) high concrete slipformed hoist tower (headframe) with integral mine ventilation exhaust stack and ore bins was built over the shaft collar. The headframe is temporarily equipped with four 4-cubic yard (3 m^3) muck buckets and adjacent ground mounted hoists for shaft sinking. Design depth is 2,004 feet (611 m) with sinking at the 832-foot (254 m) level by year end (Figures 31 and 32).
	Service Shaft - 34-foot (10.4 m) diameter: A 178-foot (54 m) tall concrete slipformed hoist tower was built over the shaft collar. The headframe is temporarily equipped with four 4-cubic yard (3 m^3) muck buckets and adjacent ground mounted hoists for shaft sinking. Shaft excavation had advanced to the 773-foot (236 m) level by year end with a design depth of 1,839 feet (561 m) (Figures 31 and 33).
	Ventilation/Escape - 15-foot (4.6 m) diameter: A 145-foot (44 m) tall enclosed steel headframe was built over the shaft collar with adjacent hoist building. The hoist is currently equipped with two 6-cubic yard (4.6 m^3) muck buckets for shaft sinking, which has advanced to the 1,016 foot (309 m) level by year end with a design depth of 1,895 feet (578 m) (Figure 34).
	A 34-foot (10.4 m) diameter ventilation air inlet tunnel was collared between the Service and Production shafts and connects with the Service shaft at 150 feet (46 m) subgrade (Figure 35).
	All shafts are concrete lined to control ground water inflow. Extensive use has been made of fore-grouting techniques to limit seepage.
Mine development	A 20 by 30 foot (6 by 9 m) mid-shaft station drift was driven between the Service and Production shafts and concrete lined.

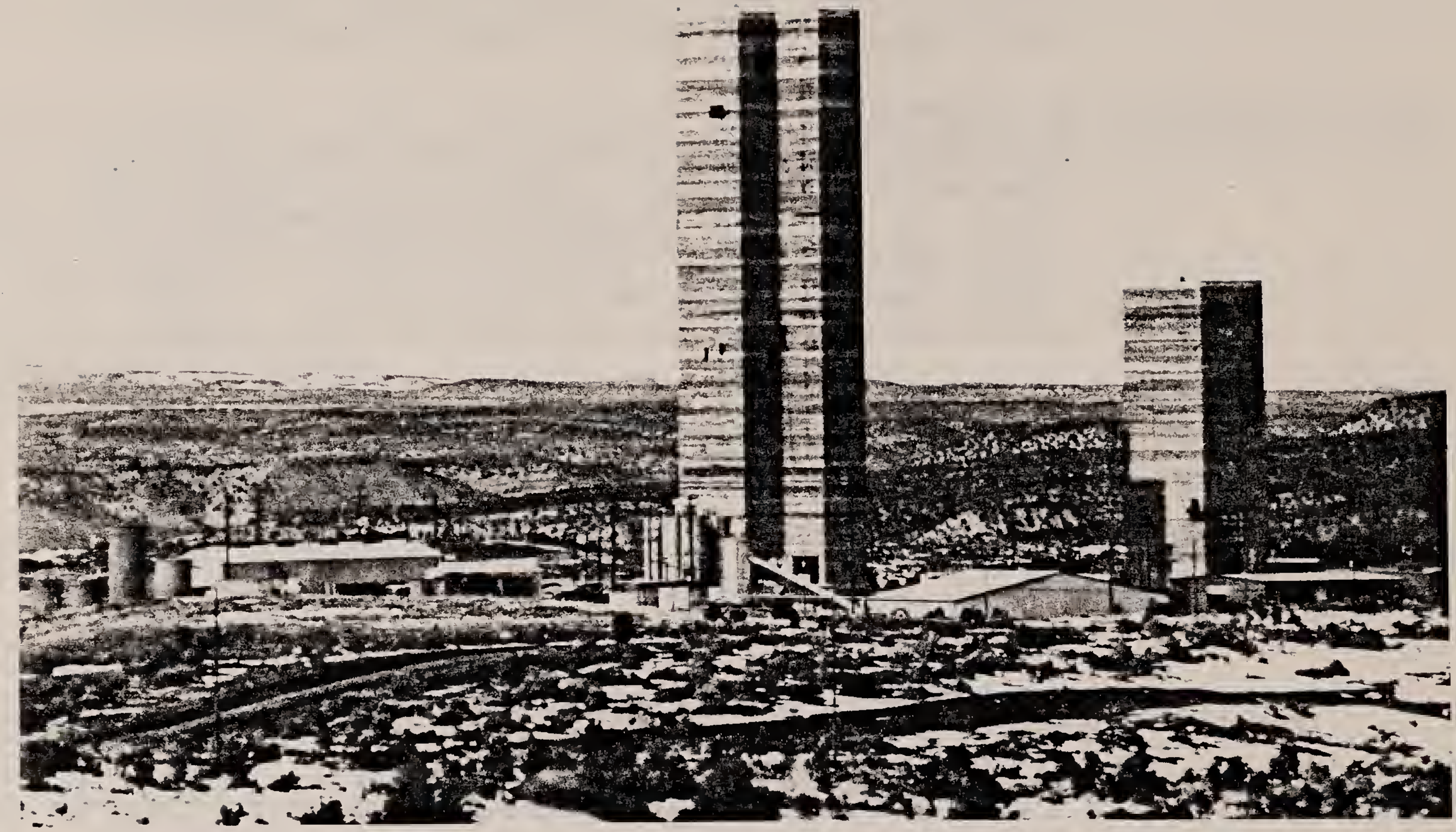


Figure 31. -- View toward northwest across Tract C-b Mine Support Area showing the two concrete slip formed hoist towers (headframes) over the commercial Service and Production shafts. The shorter tower (right) is 178 feet (54 m) tall and will house a 1,500-hp hoist for two 270-man capacity skips operating in the 34-foot (10.4 m) diameter 1,839-foot (561 m) deep Service shaft. This shaft will be used to move workers and equipment from the surface to the various mine levels. At full operation, better than 1,000 workers will ride these skips each day. The Service shaft will also be used for mine ventilation air intake through an adjacent ground level opening that interconnects 150 feet (46 m) underground.

The taller tower (left) is 313 feet (95 m) high and will house two 9,500 hp hoist works operating four 50-ton (45 t) rock skips in the 29-foot (8.8 m) diameter 2,004-foot (611 m) deep Production shaft. All material mined from various working levels and retort chambers will be hoisted in this shaft, which has a design capacity of 60,000 tons/day (5.4×10^4 t), and emptied into two 800-ton (726 t) capacity ore bins constructed inside the hoist tower. The Production shaft will also be used to exhaust ventilation air from occupied mine workings. Exhaust air will vent from the top of the smaller portion of the hoist tower.

Both hoist tower super structures are temporarily equipped with ground mounted shaft sinking hoists. These will be replaced with internal hoist works by 1983 (Figures 28 and 29). Both shafts have been excavated to approximately 800 feet and an intermediate station level drift extended between them. These shafts are concrete lined for ground control and to limit ground water seepage, which amounts to about 50 gpm (3 dm^3/s) in each shaft.

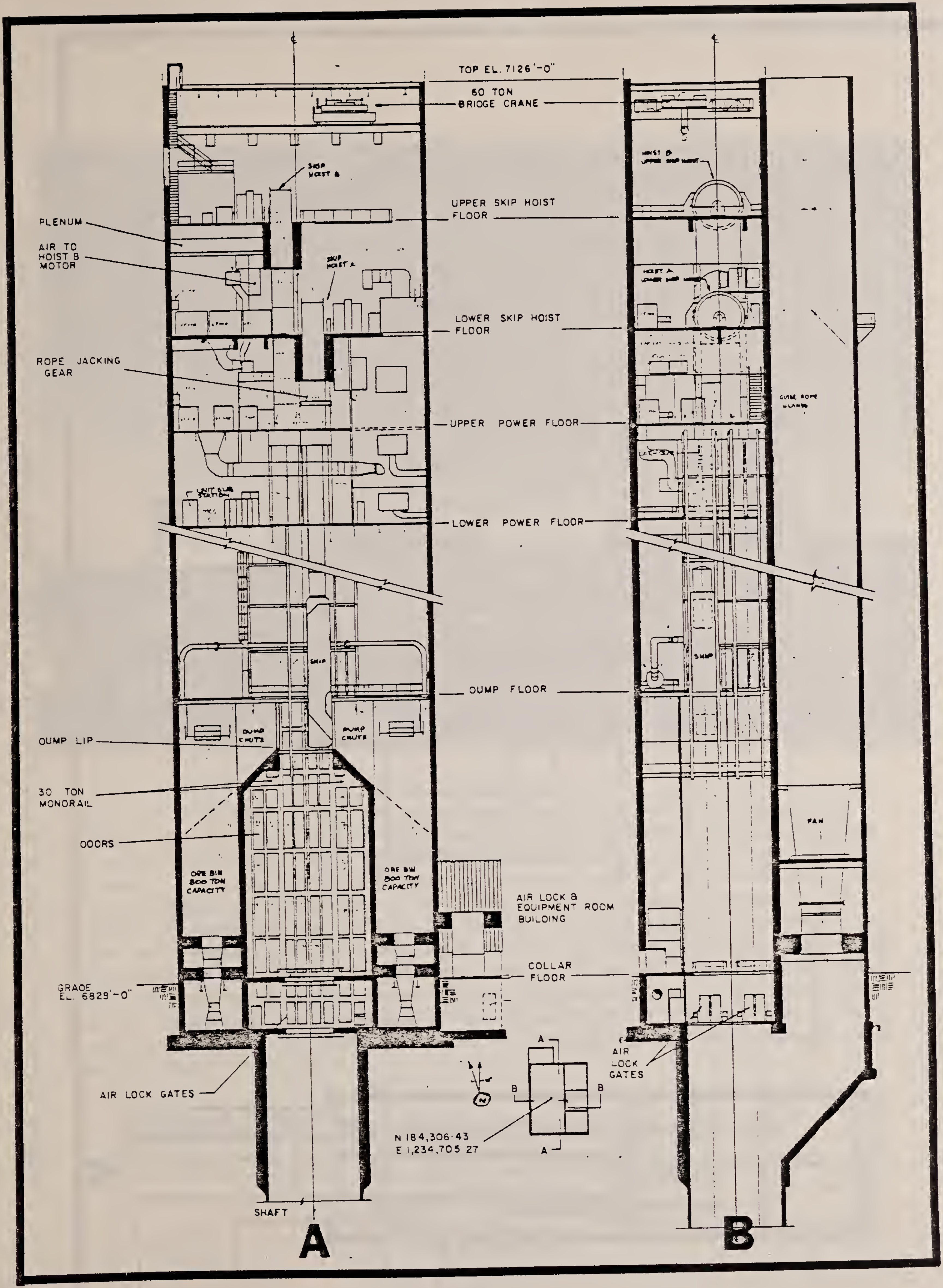


Figure 32.-- Cross section diagram of Tract C-b Production Shaft hoist tower permanent equipment

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

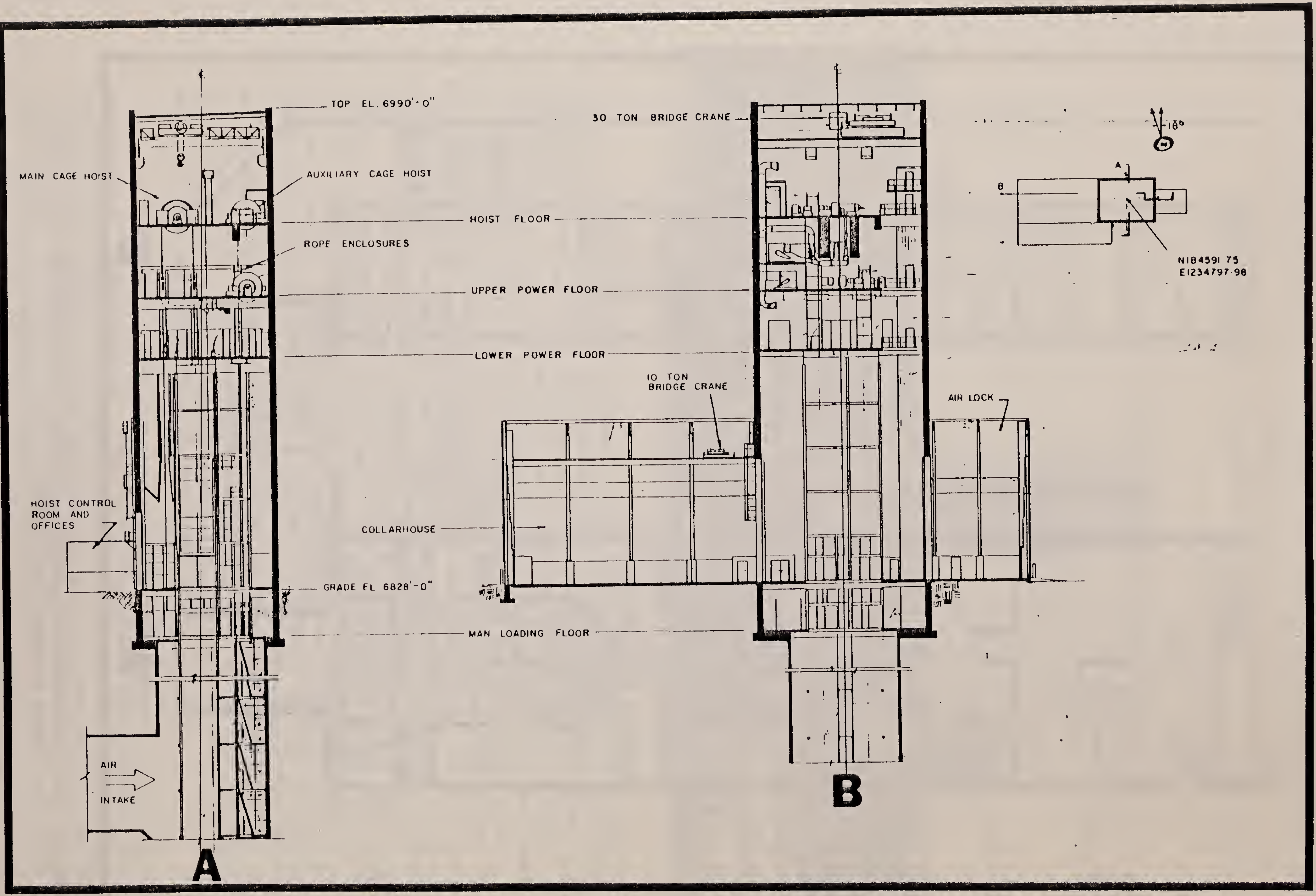


Figure 33 -- Cross section of Tract C-b Service Shaft hoist tower permanent equipment

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

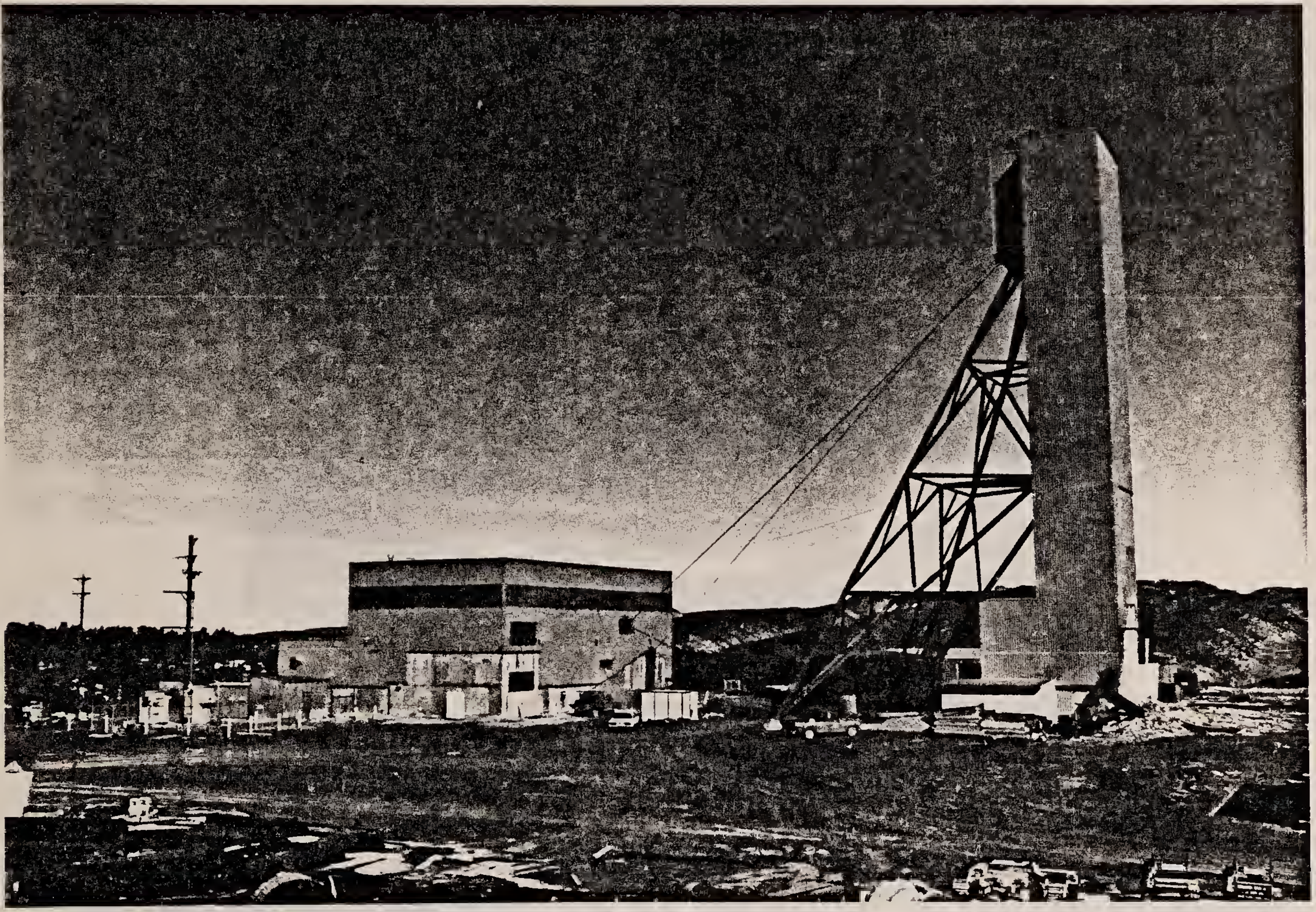


Figure 34 -- View toward north across Tract C-b Ancillary Mine Area showing the 15-foot (4.6 m) diameter Ventilation/Escape shaft headframe and hoist building. This shaft will be excavated to 1,895 feet (578 m) and used to provide secondary ventilation and exit for mine workers. The hoist building is permanently equipped with a rebuilt Norberg hoist originally assembled in 1912. The hoist is being temporarily used to raise two 6-cubic yard (4.6 m^3) muck buckets for shaft sinking, which has progressed to the 1,016-foot (309 m) level. This shaft will interconnect with the Service and Production shafts through various mine levels that will be excavated beginning in 1981. This shaft is concrete lined for ground control and to limit ground water seepage, which has averaged less than 200 gpm (13 dm^3/s).

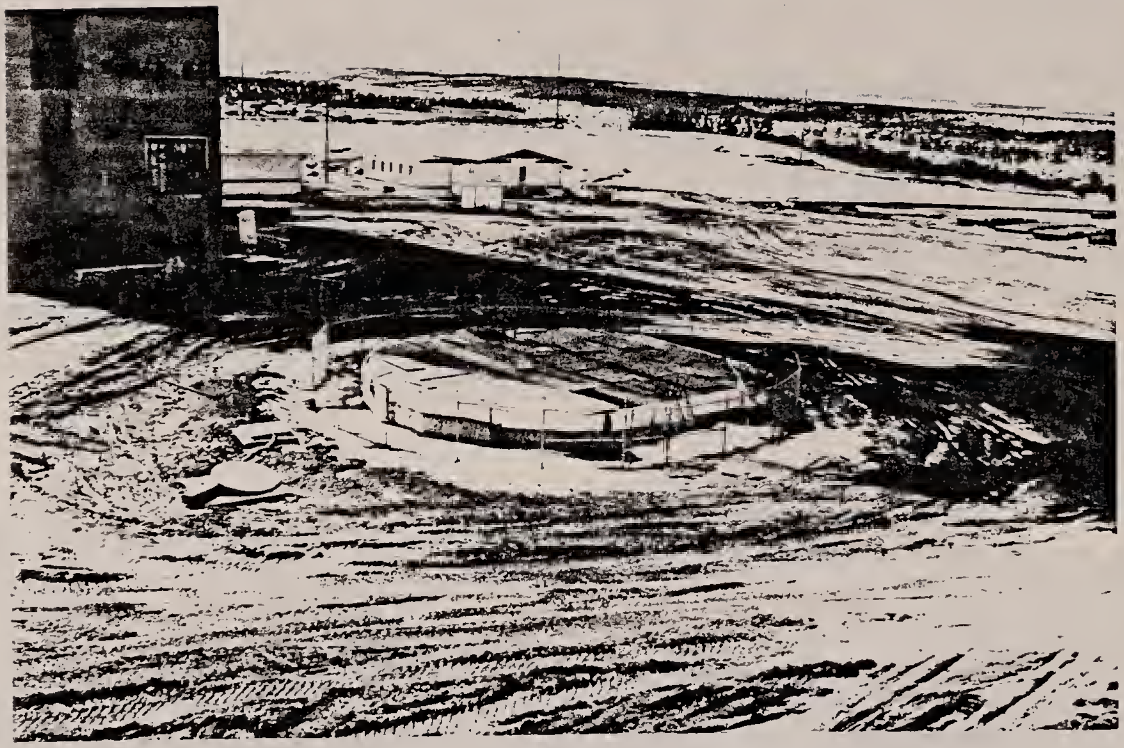


Figure 35. -- Weather sealed 34-foot (10.4 m) diameter Air Inlet Tunnel opening on Tract C-b. Ventilation air for the commercial mine workings and for operation of the MIS retorts will be drawn in through this opening which connects through a concrete lined tunnel with the Service shaft 150 feet (46 m) underground.

Facility	Description
Mine dewatering	All ground water seepage from the shafts is pumped to two treatment ponds A and B (figure 36) to settle sediments and adjust pH by addition of sulfuric acid so the water will meet NPDES permit discharge standards.
Reinjection/ irrigation	One 1,770-foot (540 m) deep test reinjection well was drilled and a 25-acre (10 ha) sprinkler land application system laid out.
Explosive storage	A one-acre (.4 ha) bermed pit east of the Mine Support Area is used to house explosive magazines. Day boxes are situated at each shaft site.
Fuel storage	Temporary tankage is provided for 39,500 gal. (150,100 L) of diesel, 10,000 gal. (38,000 L) of no-lead, and 10,000 gal. of regular gasoline. 184,000 gal. (700,000 L) diesel, 74,000 gal. (280,000 L) gasoline, 59,000 gal. (224,000 L) propane, and 139 x 10^9 BTU's of natural gas were used in 1979.
Impoundments	Ponds currently constructed on-tract include: - Two 5 acre-foot (112.4 x 10^3 m^3) ponds (A and B) for holding and treatment of up to 500 gpm (32 dm^3/s) mine seepage water prior to discharge, irrigation, or reinjection (Figures 36 and 37). - One 5-acre-foot (6.2 x 10^3 m^3) surge pond (C) for reinjection and sprinkler land application of excess mine water (Figures 38 and 39). Ponds A, B and C are interconnected by a 10-inch (25 cm) diameter pipeline. - Six erosion runoff control basins for Mine Support and Ancillary areas, run-of-mine material disposal sites, and soil stockpiles. Ponds are designed to contain runoff from a 25-year storm and to control flow from a 100-year storm.
Buildings and plants	Buildings and plants currently constructed on-tract include: - Concrete Batch Plant: 150 cubic yard (115 m^3) per hour with covered aggregate storage and 961 cfm (453 dm^3/s) dust collection baghouse (Figures 40 and 41). This plant produced 19,000 cubic yards (1.5 x 10^4 m^3) of concrete in 1979 to line the mine shafts. - Generator Plants: Five unit 1,000 KW OXY standby diesel generator plant for concrete batch plant and administrative area emergency standby power, and

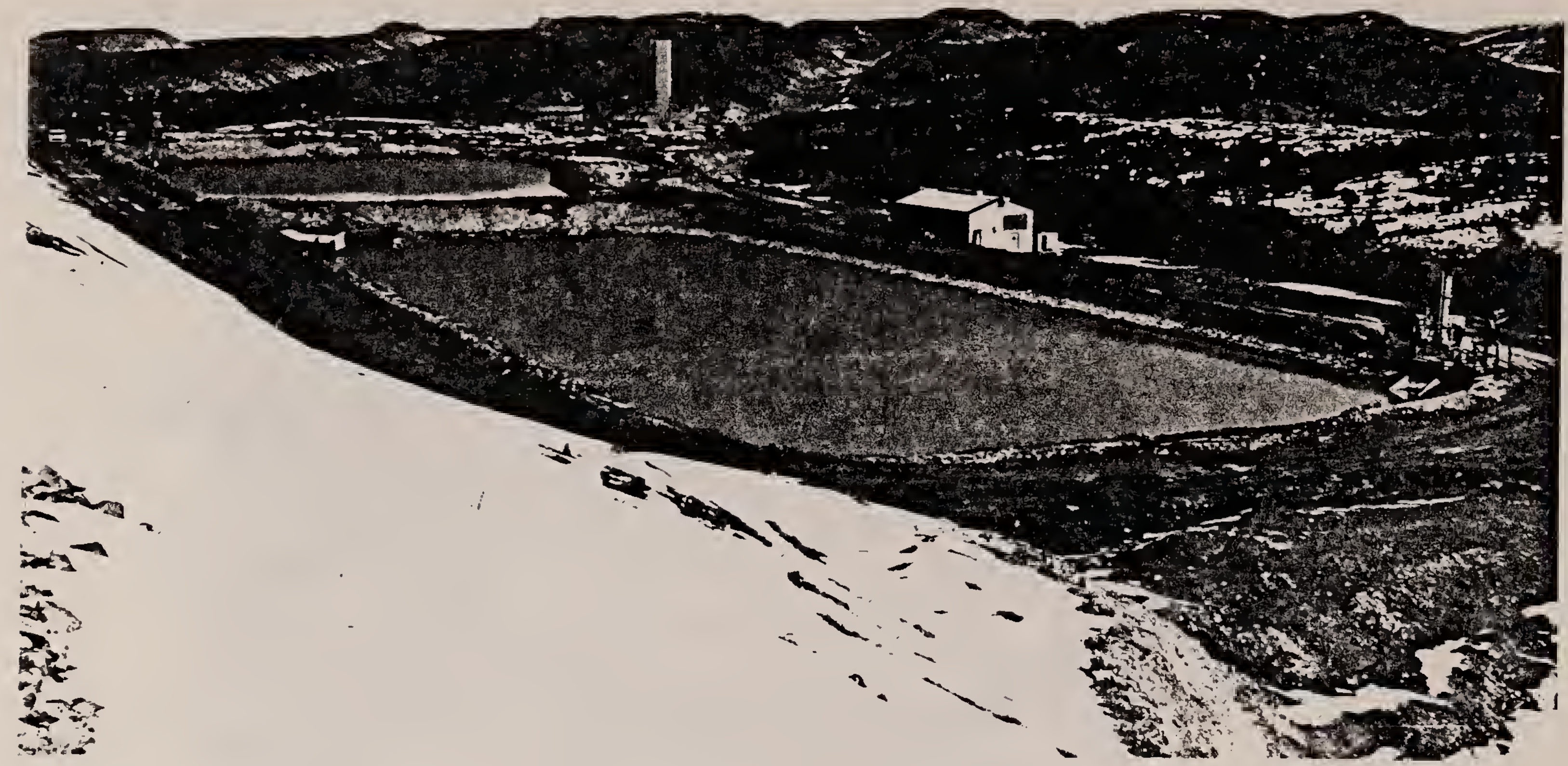


Figure 36. -- Photograph of two 5 acre-foot (12.4 x $10^3 m^3$) mine water settling and treatment ponds (Ponds A and B) located on Tract C-b adjacent to the Mine Support Area. All ground water seepage into the shafts is pumped here for settling of suspended solids and pH adjustment. Pumps in small building (center, right) will be used to move water to a higher, third pond to the south for disposal by sprinkler application to undisturbed tract areas or reinjection through deep wells. Treated water is presently released to tree lined No-Name Gulch (right). Nearly 110-acre feet of water was processed through these ponds in 1979.

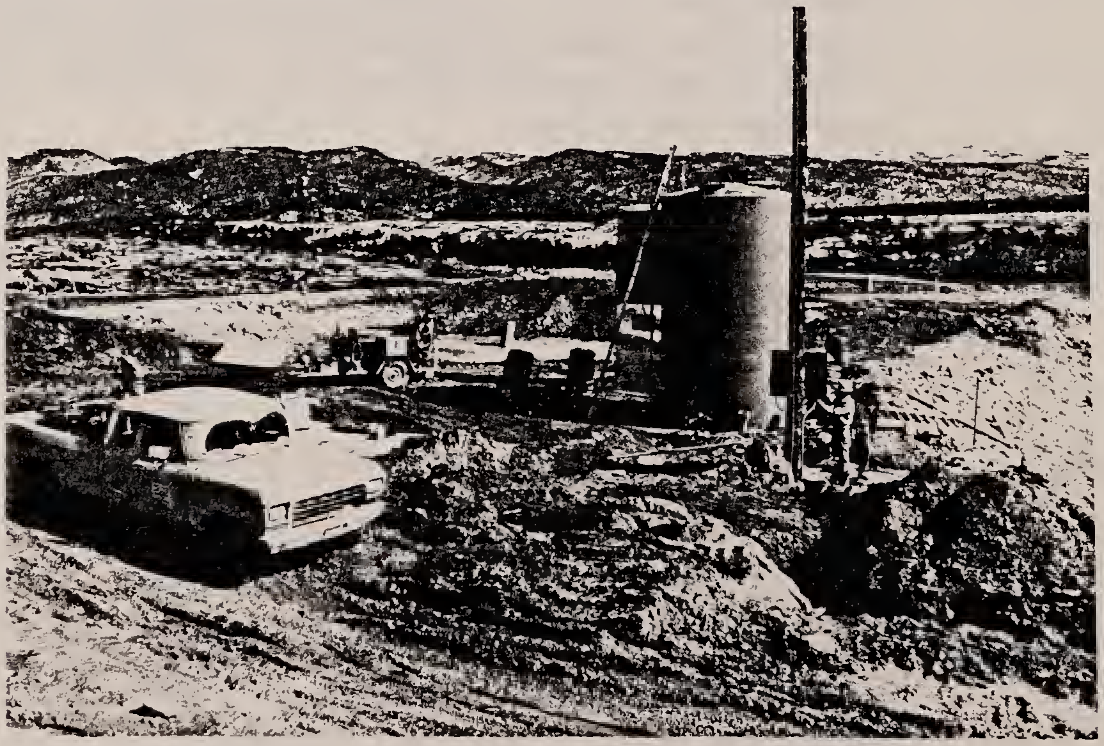


Figure 37. — Photograph of installation of acid storage tank and automatic metering equipment at the north end of the two 5 acre foot mine water settling/ treatment ponds on Tract C-b. This facility will automatically add acid to incoming mine drainage water to adjust pH to NPDES permit requirements prior to surface discharge.

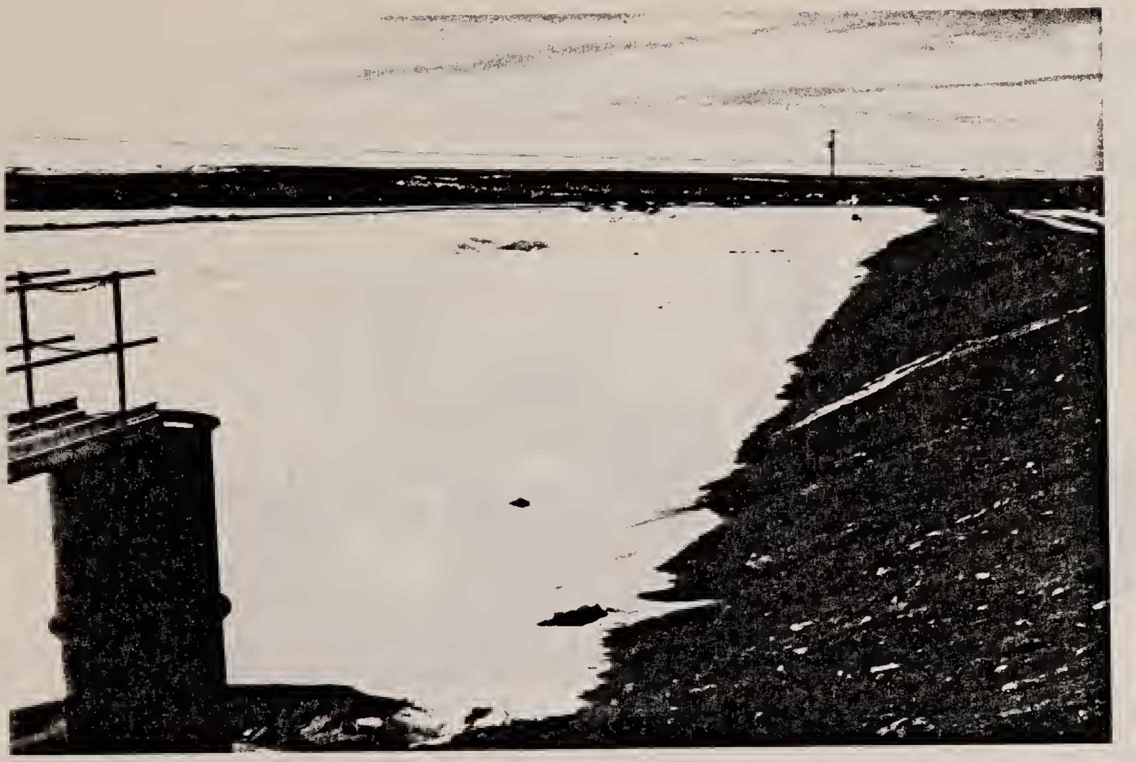


Figure 38. — Photograph of 5 acre-foot mine water surge pond (Pond C) on Tract C-b from which treated and filtered mine water will either be applied by a system of irrigation sprinklers to undisturbed tract areas or reinjected into a deep test well. Distribution lines for the sprinkler system are inplace and one test reinjection well just west of this pond has been drilled and cased. Both well and irrigation system will be placed into operation during 1980.

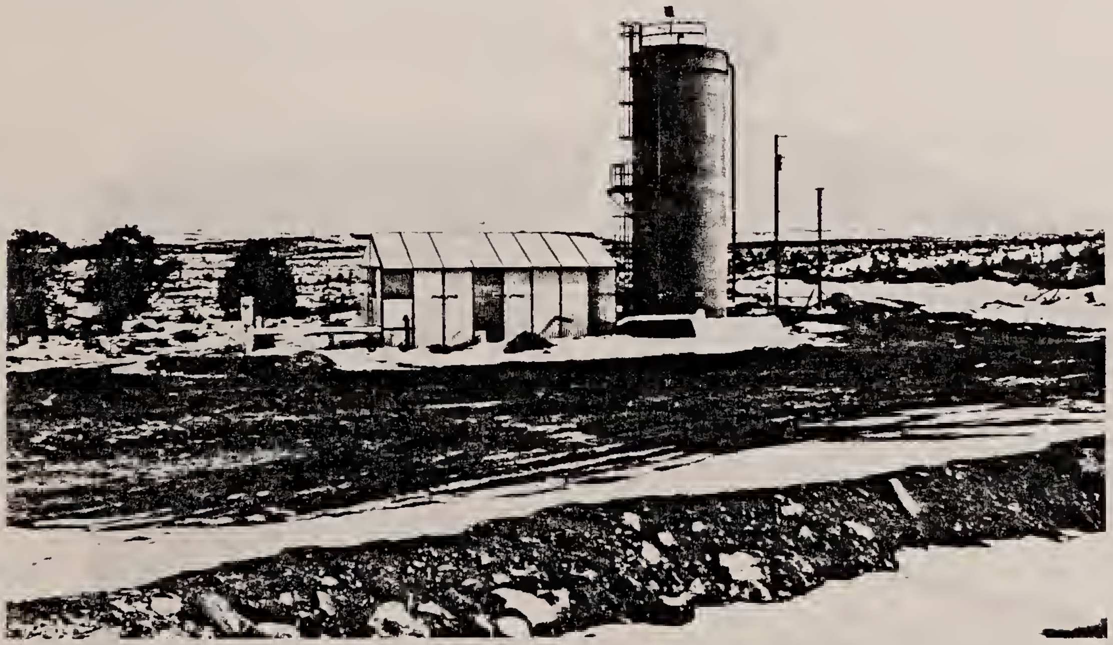


Figure 39. — Photograph showing pump house and surge tank on Tract C-b for sprinkler application and reinjection of excess treated mine seepage water. These facilities are located adjacent to the above pictured Pond C.

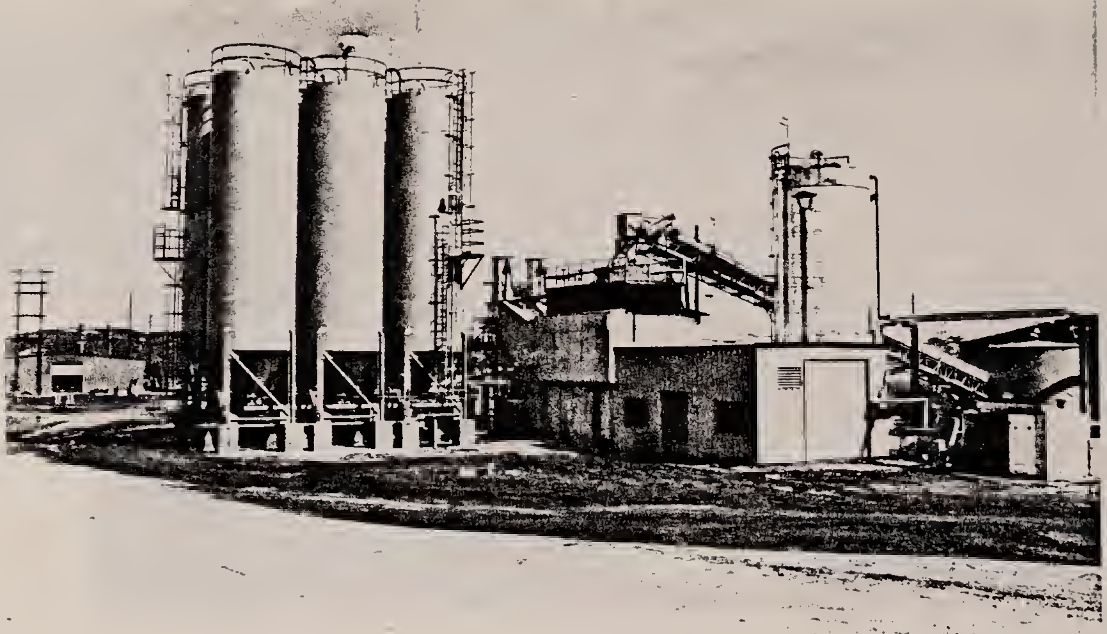


Figure 40. -- Photograph of Tract C-b permanent 150-cubic yard (115 m^3) per hour concrete batch plant. This plant provided concrete for the Service and Production Shaft hoist towers and foundations for other on-site facilities. The batch plant presently provides concrete for lining the Service, Production, and Ventilation/Escape shafts.

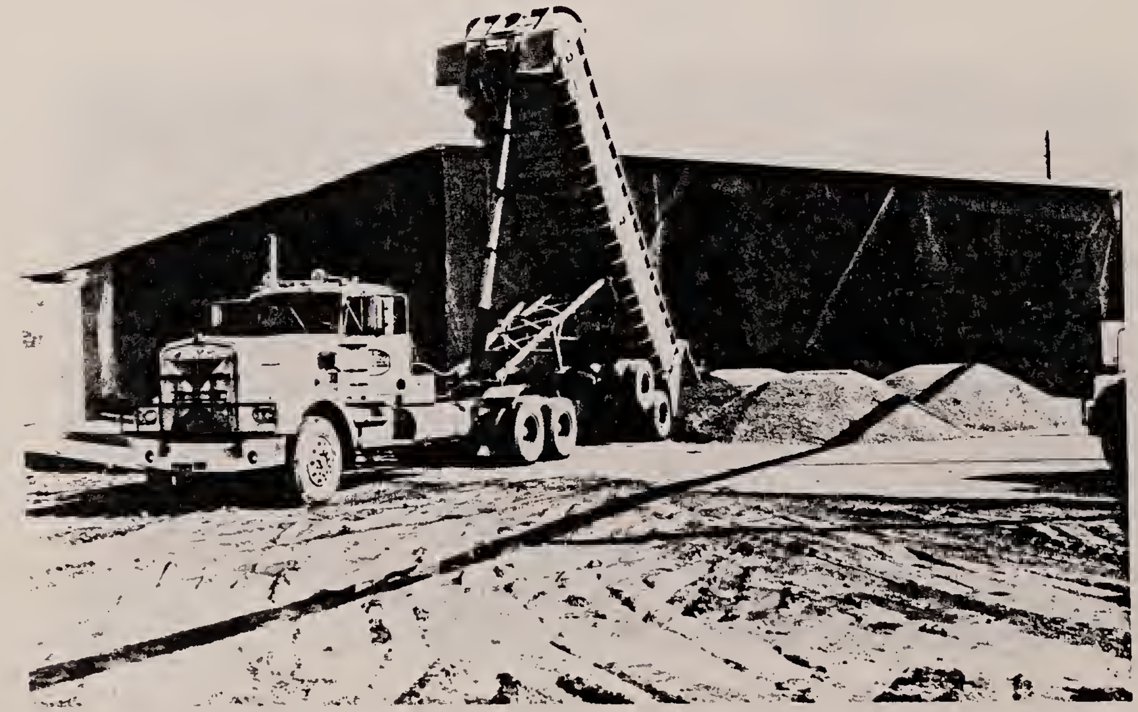


Figure 41. — Photograph of the all weather aggregate storage bins located adjacent to the Tract C-b concrete batch plant (pictured above). The bins are fitted with steam lines to thaw frozen aggregate during winter weather.

Facility	Description
	seven 1000 hp unit 5,000 KW natural gas fueled generator plant for shaft sinking with tie over to other on-tract facilities (Figure 42). - Shops/Compressors: Two fully equipped mine shops and air compressor plants, one each at Mine Support and Ancillary areas. - Warehouses: Two temporary warehouses and four laydown yards on-tract, and one 5,000 sq. ft. (465 m^3) storage building in Rifle for receiving permanent hoisting equipment (Figure 43). - Administrative: Ten office trailers for administrative and dry room facilities (Figure 44), and permanent Occidental Oil Shale, Inc., office and laboratory in Grand Junction, Colorado. - Health Care: One slab mounted first aid trailer, and one fully equipped field ambulance housed in permanent steel span building with space for fire truck. - Security: One guard building at access road entrance with truck weighing facility. - Heliport: Leveled area and small waiting building adjacent to access road near north boundary to be served by company owned Bell Longranger.

Tracts U-a and U-b

Status

Development of Tracts U-a and U-b has been delayed by legal action including cases stemming from Utah's statehood land selection rights (in-lieu lands) and unvacated prior mining claims. In the former case, the U.S. District Court's (Salt Lake City), *Findings of Fact, Conclusion of Law, and Decree of June 8, 1976*, favored Utah's position that "indemnity selections" of in-lieu lands in Uintah County could be made acre-for-acre, rather than the Department of Interior's position of value-for-value under the Taylor Grazing Act. The United States Court of Appeals, Tenth Circuit (Denver) on August 8, 1978, ruled in support of Utah's claim to 157,255.90 acres (63,688.6 ha) of land which include Federal Oil Shale Lease Tracts U-a and U-b.

On May 18, 1977, the lessees of Tracts U-a and U-b filed suit against the Department of Interior seeking an injunction to indefinitely suspend lease diligent development requirements including bonus bid payments, until conflicts with overlapping mining claims and state selection of lands were resolved. A hearing was held on June 3, 1977, and continued to June 8, 1977, when a preliminary injunction was granted (Civil No. C77-0165) which stated

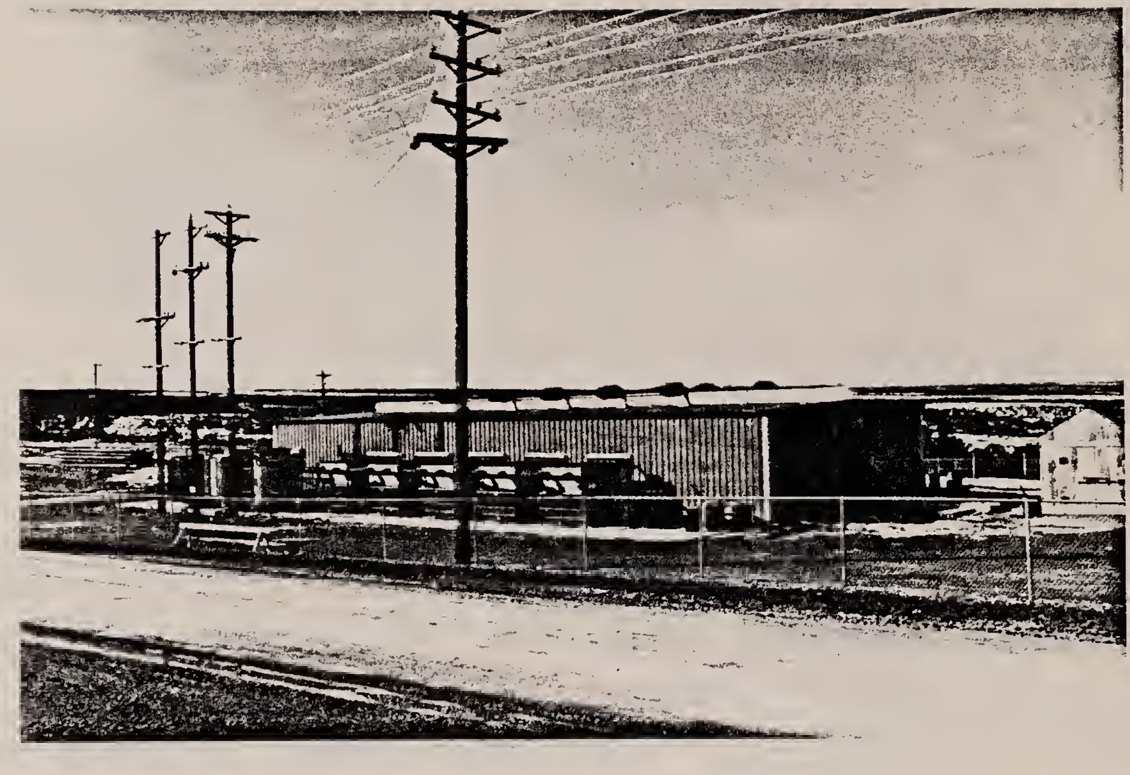


Figure 42.-- Photograph of Tract C-b power-generating plant. The building houses seven 1,000 hp natural gas fueled diesel units producing 5,000 KW for shaft sinking with tie-over to administrative offices and other interruptable loads. The plant will be replaced in 1981 with an overland 138 KVA powerline from Meeker, Colorado. Thereafter, the on-site plant will provide emergency standby power in accord with safety regulations.

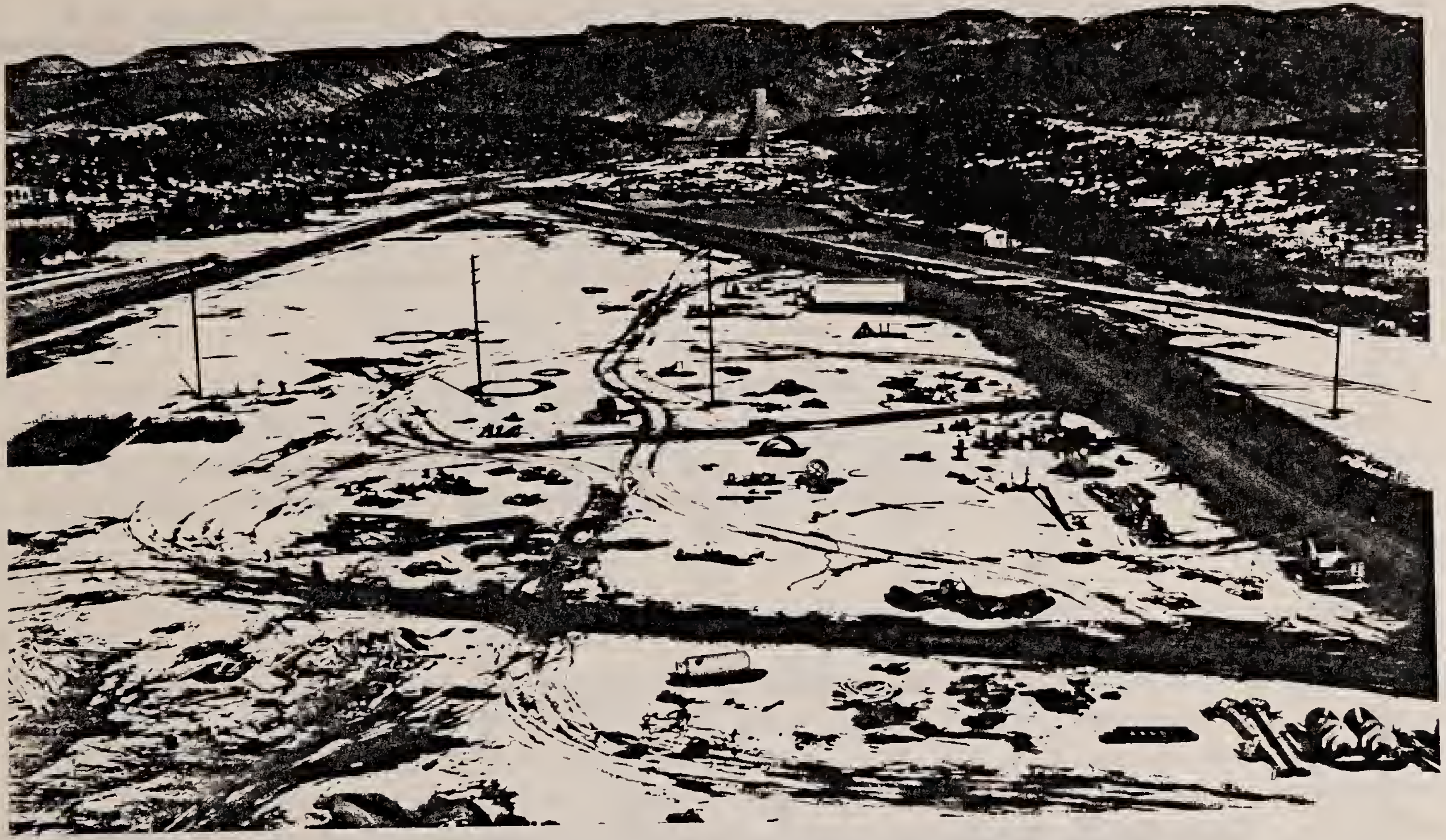


Figure 43 -- View toward the north showing Tract C-b Mine Support Area from atop Service Shaft hoist tower. Ancillary Mine Area with the Ventilation/ Escape shaft headframe can be seen in the distance. Highland area beyond headframe is the Piceance Creek Dome on the north side of Piceance Creek Valley. Cleared and leveled area in foreground will be the site of permanent warehouses, offices, change house, and sewage and water treatment facilities. The existing two 5 acre-foot mine water treatment/settling ponds can be seen at upper right.

Figure 44 -- Photograph of temporary administration offices for management and engineering personnel at Tract C-b. Microwave tower provides direct dial telephone service to Grand Junction.

that "The Secretary of Interior and any of his agents or subordinates are enjoined from seeking to enforce the terms and conditions of (the) Leases of Tracts U-a and U-b or any of the obligations...thereunder in any manner...during the pendency of this action."

Fate of Tracts U-a and U-b now rests with the U.S. Supreme Court which is expected to rule shortly on the December 5, 1979, filing of the Justice Department's appeal to district court findings in favor of Utah's land selection claim.

A DDP was submitted by the joint venture (White River Shale Project) for development of the two Utah tracts by underground mining and surface retorting. The plans, however, have not been reviewed or acted on by the AOSO due to the ensuing suspension of operations and court order injunction.

Mining

The 15-foot (4.6 m) diameter Service/Production shaft on Tract C-a was sunk by conventional drill-blast-muck methods to a design depth of 979 feet (299 m) below the collar. Approximately 30,000 tons (2.7×10^7 kg) of material were removed during shaft excavation using a Cryderman mucking machine. The shaft was lined with a minimum of one-foot (.3 m) thickness of concrete. Two 10-foot (3 m) diameter 971-foot (269 m) deep Ventilation and Secondary Escape/Service shafts were upreamed from "G" production mine level together with eight-foot (2.4 m) diameter ore passes from "G" to "C" levels. A loading pocket was completed in the bottom of the Service/Production shaft. An additional 16,444 tons (1.5×10^7 kg) of material have been removed from approximately 2,000 feet (610m) of mine level (principally "G" level) drifts completed to date for development of MDP retorts. Drilling started on Retort "0" blast holes in August of 1979. MDP mine and retort facilities planned and completed are depicted in figures 45 and 46.

During shaft sinking and lateral development on Tract C-a, approximately 6,000 acre-feet (7.4×10^6 m^3) of mine seepage water was removed through a combination of peripheral dewatering wells and mine sumps. Pumping rates ranged from 1,200 to 3,000 gpm (76 to 190 dm^3/s).

Headframes for the three commercial size shafts on Tract C-b were in place by January of 1979, and by spring temporarily outfitted for shaft sinking (Figures 47 and 48). Shaft excavation was the principal mine development work on Tract C-b during 1979. Approximately 128,400 tons (1.2×10^8 kg) of development rock have been mined from the shafts and mid-shaft station drift between the Service and Production shafts by year end.

The 15-foot (4.6 m) diameter Ventilation/Escape shaft on C-b is being sunk by conventional drill-blast-muck methods using a Cryderman mucking machine loading two 6-cubic yard (4.6 m^3) buckets. The shaft is being lined with a minimum thickness of one-foot of concrete for ground and water seepage control.

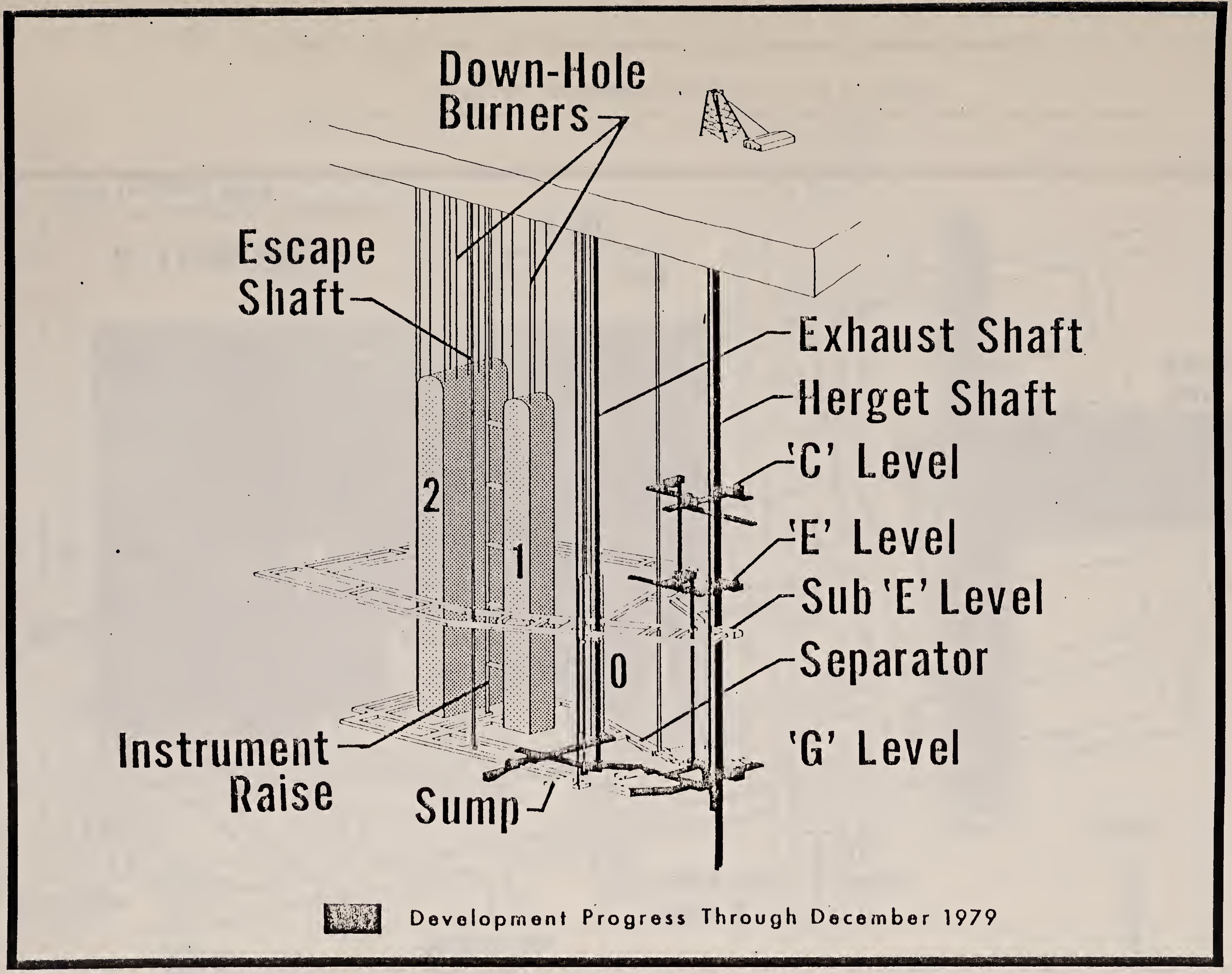


Figure 45. -- Diagram of Tract C-a mine development progress

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

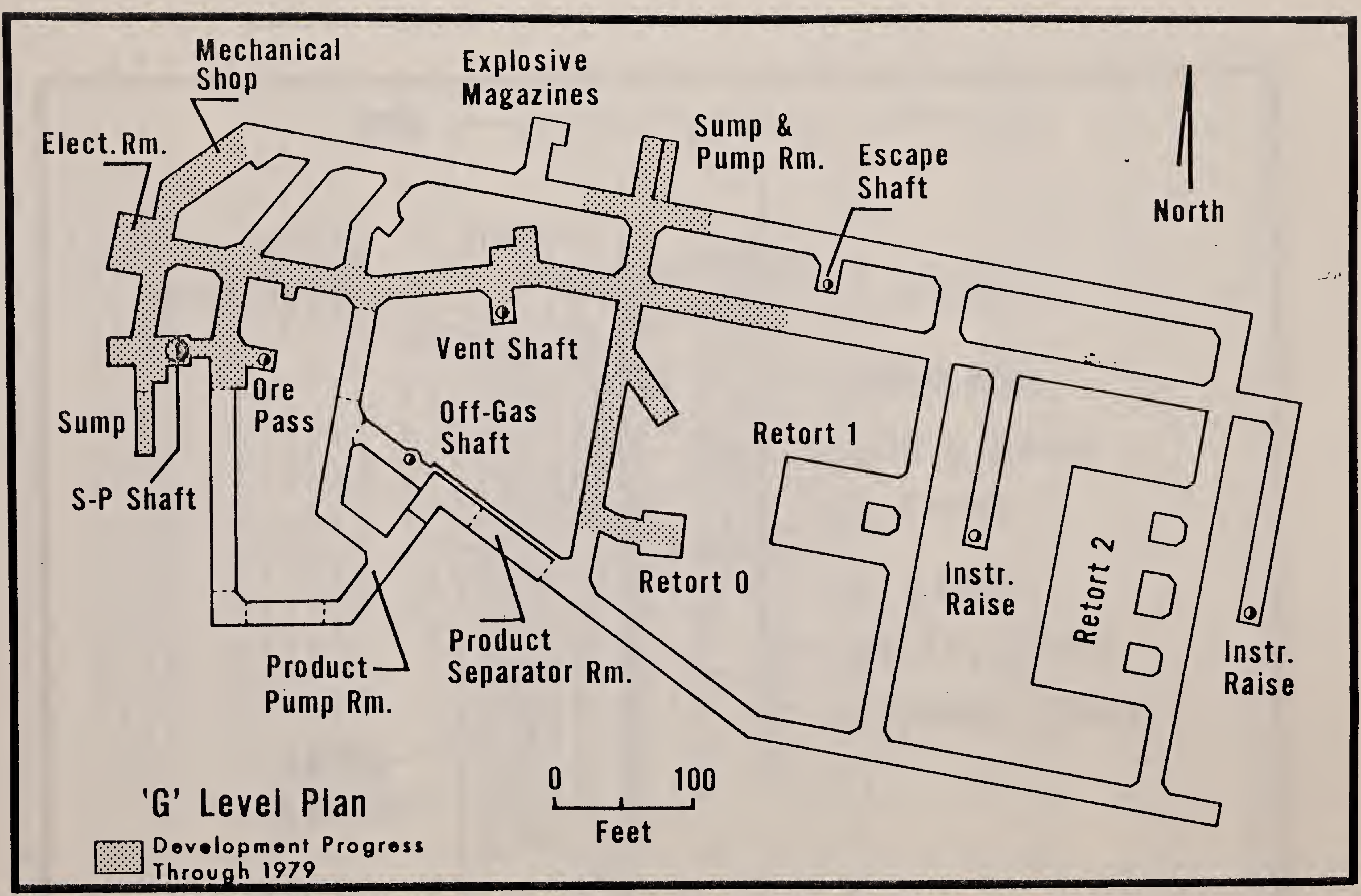


Figure 46. -- Diagram of Tract C-a "G" mine level plan (cross hatched areas indicate workings completed by end of 1979)

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

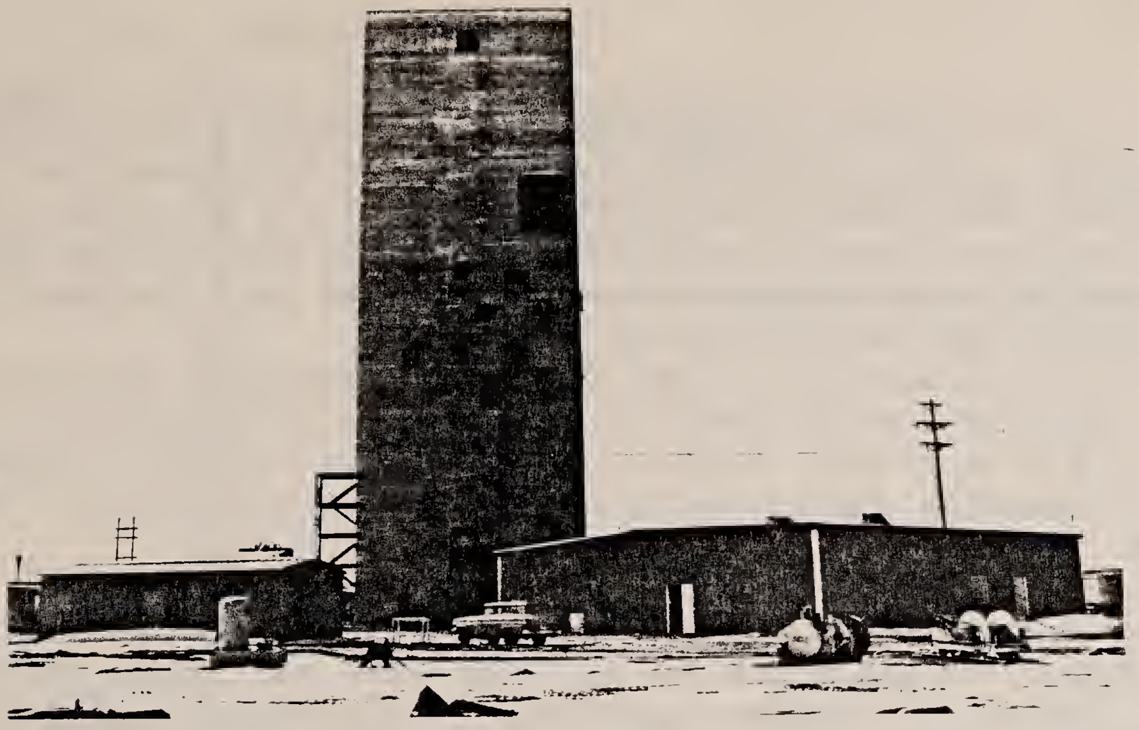


Figure 47. -- Photograph of the north face of the Service shaft hoist tower on Tract C-b showing temporary ground-mounted hoists and winches for shaft sinking (buildings in foreground). Sinking hoists and temporary cable openings left in the side of the concrete super structure will be removed in 1982 and permanent hoist works for commercial mine operation will be installed within the concrete hoist tower.

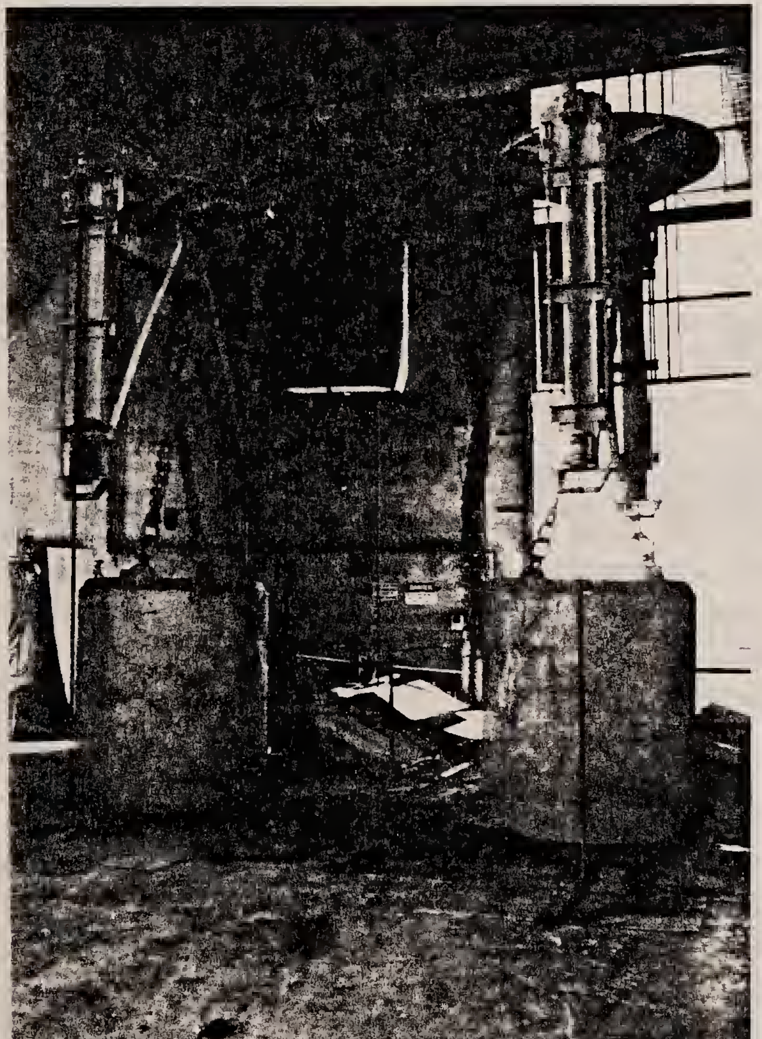


Figure 48. -- Ground level view inside the Tract C-b Service shaft hoist tower showing three of the four 4-cubic yard (3 m^3) muck buckets being used to raise material excavated from shaft bottom, pump stations, and mine levels. Hydraulic doors in the floor close after each bucket is raised prior to their being dumped into overhead muck shutes to prevent debris from falling back down the shaft. The Production and Ventilation/ Escape shafts are equipped with similar safety doors.

The 34-foot (10 m) diameter Service shaft and 29-foot (8.8 m) diameter Production Shaft on Tract C-b are being developed by conventional bench methods with muck being excavated by 1¼-cubic yard (.9 m^3) diesel crawler loaders filling four 4-cubic yard (3 m^3) muck buckets in each shaft. Both shafts are being concrete lined for ground and water seepage control.

A 34-foot (10 m) diameter Air Inlet Tunnel was completed on Tract C-b. It connects with the Service shaft at 150 feet (46 m) subgrade. A 20-by 30-foot (6 by 9 m) mid-level station drift has been excavated between the Service and Production shafts for cross access, ventilation, and roping shaft hoists.

The method of ground water control used on C-b during shaft sinking involves grouting through boreholes drilled below and beyond the perimeter of the shafts in advance of sinking. The grouting scheme for the Ventilation/Escape shaft is depicted in figure 49. Mine water seepage has been limited in this manner to generally less than 300 gpm (19 dm^3/s) combined flow in all three shafts.

Mine development progress and problems on both tracts were routinely discussed with the USGS. One of the significant problems was adequate monitoring of the mine atmosphere to determine adequacy of ventilation. Continuous monitors were initially installed near the shaft bottom on Tract C-a to directly sample the exhaust air stream. High moisture levels, blasting concussion, and dust, however, caused the instrumentation to malfunction producing erroneous readings. Procedures were then established for monitoring the mine atmosphere using hand held detectors while the continuous monitors were moved to the collar of the ventilation shaft.

Varying concentrations of methane were recorded in the C-a mine. Significant methane build-up occurred when shaft sinking reached the top of the rich R-5 oil shale zone. As soon as methane was detected, the lessee and the Area Oil Shale Office established precautionary measures to guard against a possible ignition. Nevertheless, two minor ignitions did occur in the Service/Production shaft in the area where cutting torches were in use. These incidences together with methane readings above permissible levels resulted in the Mine Safety and Health Administration (MSHA) declaring the C-a mine "gassy" on November 30, 1979. Another minor ignition has subsequently occurred in the "G" level substation. For similar reasons, the C-b mine was also declared gassy during the first month of 1980.

Extensive rock bolting, grouting, and shotcreting have been used on both Colorado tracts to insure back and rib stability during mine level development. On Tract C-a, cribbing and steel supports were also required to support badly fractured ground on sub-E level.

Shaft depths and ground water inflow at the indicated depths as of December 31, 1979, are summarized in table 7:

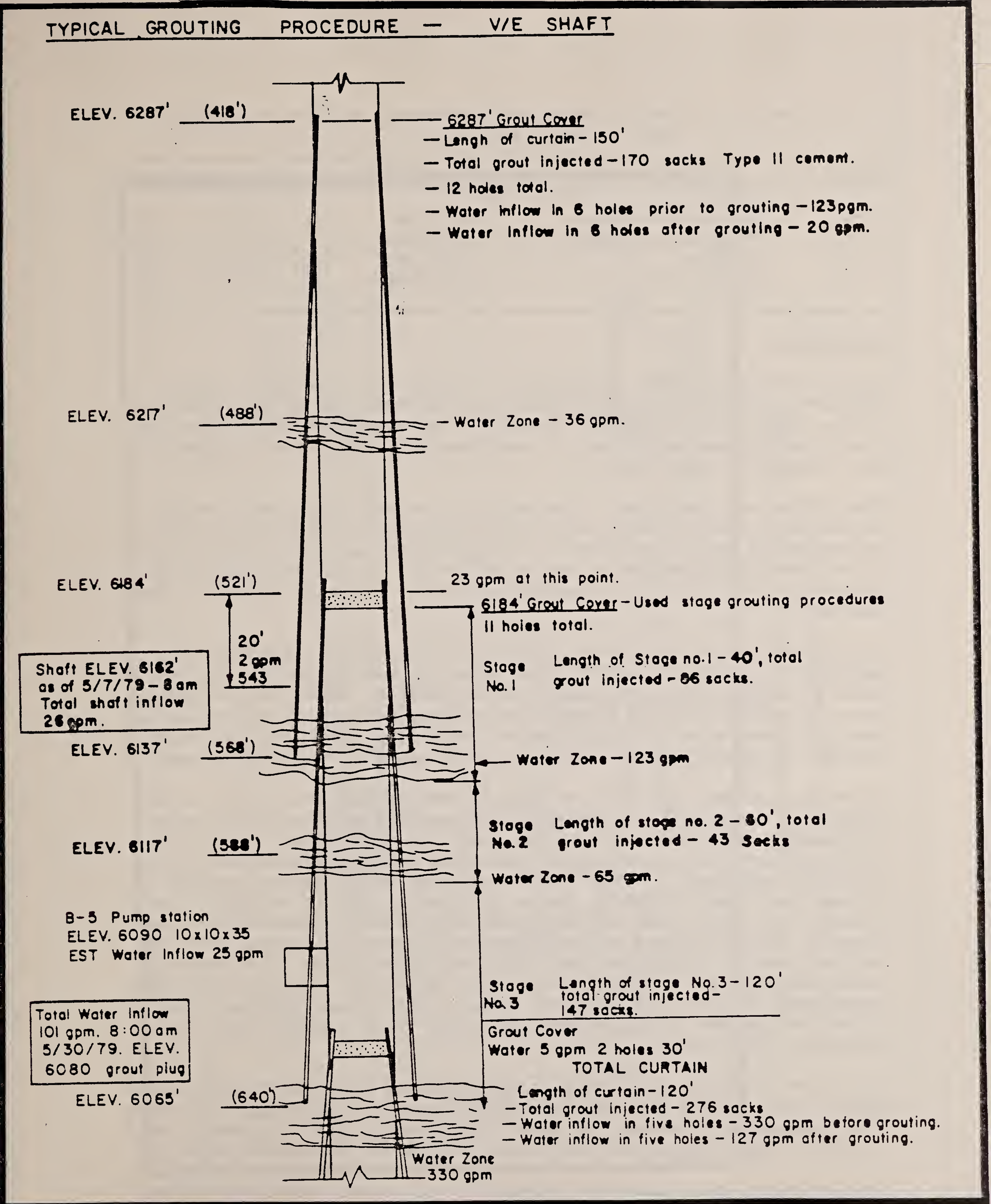

TYPICAL GROUTING PROCEDURE — V/E SHAFT
ELEV. 6287' (418')
6287' Grout Cover
— Lengh of curtain - 150'
— Total grout injected - 170 sacks Type II cement.
— 12 holes total.
— Water inflow in 6 holes prior to grouting - 123 pgm.
— Water inflow in 6 holes after grouting - 20 gpm.
ELEV. 6217' (488')
— Water Zone - 36 gpm.
ELEV. 6184' (521')
23 gpm at this point.
6184' Grout Cover - Used stage grouting procedures
11 holes total.
20'
2 gpm
543
Shaft ELEV. 6162' as of 5/7/79 - 8 am Total shaft inflow 26 gpm.
Stage No. 1
Length of Stage no. 1 - 40', total grout injected - 86 sacks.
ELEV. 6137' (568')
Water Zone - 123 gpm
Stage No. 2
Length of stage no. 2 - 80', total grout injected - 43 Sacks
ELEV. 6117' (588')
Water Zone - 65 gpm.
B-5 Pump station
ELEV. 6090 10x10x35
EST Water Inflow 25 gpm
Stage No. 3
Length of stage No. 3 - 120' total grout injected - 147 sacks.
Total Water Inflow 101 gpm. 8:00 am 5/30/79. ELEV. 6080 grout plug
Grout Cover
Water 5 gpm 2 holes 30'
TOTAL CURTAIN
Length of curtain - 120'
— Total grout injected - 276 sacks
— Water inflow in five holes - 330 gpm before grouting.
— Water inflow in five holes - 127 gpm after grouting.
ELEV. 6065' (640')
Water Zone
330 gpm

Figure 49. — Sketch of typical grouting scheme used on Tract C-b (V/E shaft) for ground water seepage control during shaft sinking

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

Table 7. -- Shaft depth and approximate mine water inflow rates by year's end 1979

Tract	Shaft	Water Inflow	Depth Below Collar
C-a	Service/Production	1,235 gpm	971 ft
C-b	Ventilation/Escape	167 gpm	1,016 ft
C-b	Service	35 gpm	773 ft
C-b	Production	45 gpm	832 ft

Processing

Approved DDP's call for development of Tract C-a by modified in-situ (MIS) and possible aboveground retorting, and Tract C-b by MIS retorting. At the time of court ordered injunction, the unapproved DDP for the two Utah tracts presented a plan of development by room-and-pillar mining with aboveground retorting.

The MIS process involves a combination of direct mining and in-situ retorting to produce shale oil. Permeability within the oil shale formation needed for flow-through of injected gases and removal of products is achieved by mining out a portion of the oil shale, and drilling and explosively rubblizing the remainder in place. The rubbled shale is then ignited.

To initiate combustion, burners are placed on top of the rubble. As depicted in figure 51, air is then either pulled through the rubbled shale by exhaust blowers or fed in under pressure. When reaction temperature of 900°F (480°C) is reached, the burners are turned off. Retorting rate and temperature is controlled by regulating the volume and oxygen content of injected air by adding diluting steam or recycled off-gas.

Prior to ignition, the mine production level beneath the retorts to be kindled is sealed off (bulkheaded) from workings being used for retort development. The sealed section is tied into the off-gas ventilation circuit by remotely knocking down previously established bulkheads (probably with explosives). Retort gases are drawn to the surface through the off-gas shaft and treated to remove pollutants prior to release to the atmosphere. These gases may be burned on-site during commercial operations in special boilers or gas turbines to generate steam and power for on-tract needs. Product oil and water will gravity flow to a system of sumps and be pumped through oil-water-gas separators to surface storage tanks prior to off-tract shipment. Retort and process sour water will either be disposed of in evaporation ponds, or by special high brine treatment facilities.

Tract C-a is currently building a retort off-gas treatment plant and oil recovery and storage facility for the MDP retorts. The Industrial Company (TIC) completed 99 percent of these facilities in 1979. Figures 51 and 52 show a flow diagram and plot layout for the MDP processing facility.

The C-a plant steam generator (Figure 53) will supply steam for surface processing and for injection with the retort air supply to control retort temperature and rate of flame-front advance. Oil and sour water will

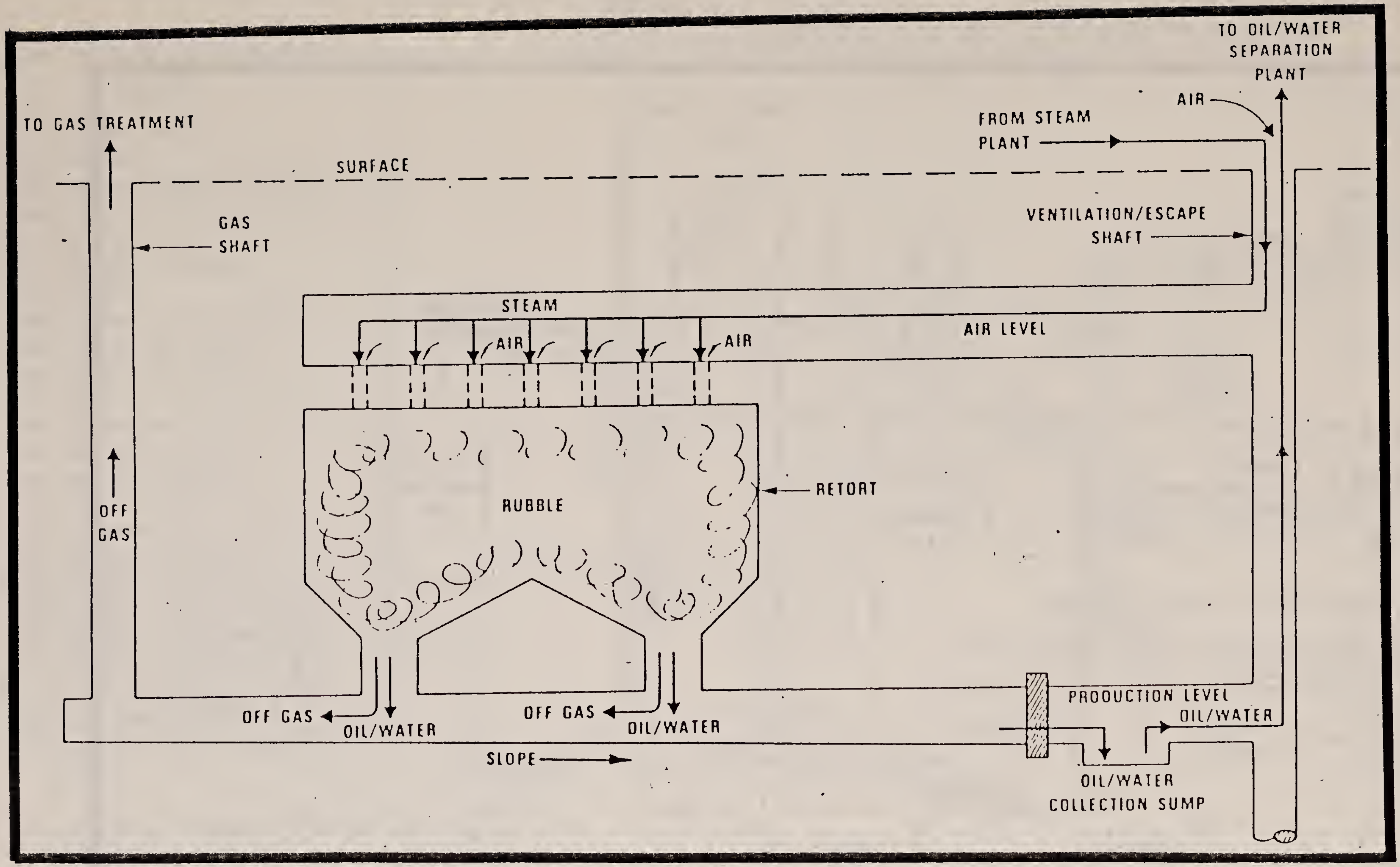


Figure 50. -- Schematic diagram of modified in-situ retorting

From: Cathedral Bluffs Shale Oil Company, 1977.

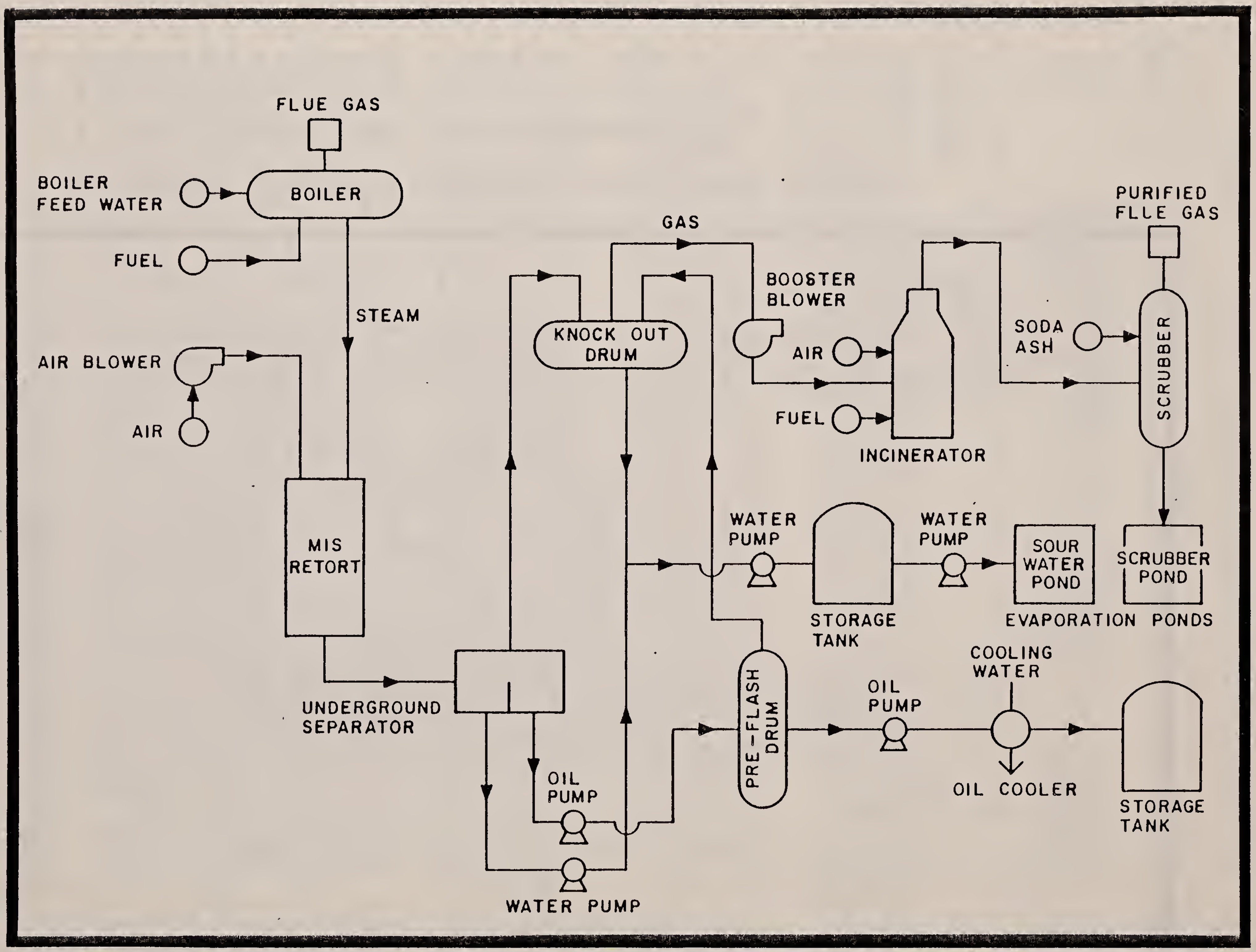
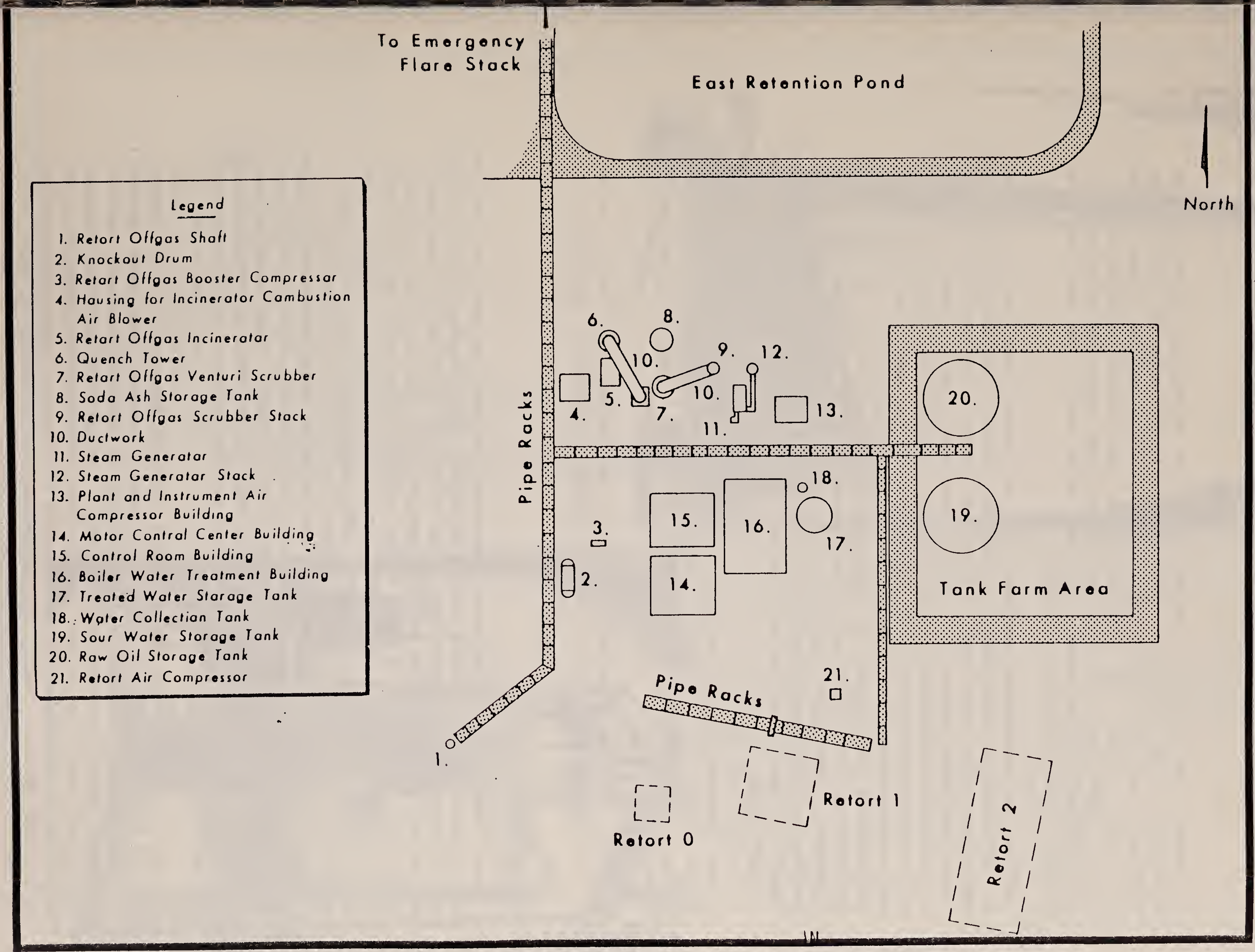


Figure 51. -- Flow diagram of Tract C-a Modular Development Phase retort off-gas treatment and oil collection facility

From: Rio Blanco Oil Shale Company, 1979.


To Emergency Flare Stack
East Retention Pond
North
Legend
1. Retort Offgas Shaft
2. Knockout Drum
3. Retort Offgas Booster Compressor
4. Housing for Incinerator Combustion Air Blower
5. Retort Offgas Incinerator
6. Quench Tower
7. Retort Offgas Venturi Scrubber
8. Soda Ash Storage Tank
9. Retort Offgas Scrubber Stack
10. Ductwork
11. Steam Generator
12. Steam Generator Stack
13. Plant and Instrument Air Compressor Building
14. Motor Control Center Building
15. Control Room Building
16. Boiler Water Treatment Building
17. Treated Water Storage Tank
18. Water Collection Tank
19. Sour Water Storage Tank
20. Raw Oil Storage Tank
21. Retort Air Compressor
Pipe Racks
Pipe Racks
Tank Farm Area
Retort 0
Retort 1
Retort 2
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
10.
11.
12.
13.
14.
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16.
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18.
19.
20.
21.

Figure 52. -- Plot diagram of Tract C-a Modular Development Phase retort off-gas treatment and oil collection facility

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

be pumped from collection sumps through an underground gas-oil-water separator. From there, the crude shale oil is pumped to the surface treatment plant and through an oil/gas preflash separator drum (Figure 54), water cooled, and finally pumped into surface storage tanks. Initial crude shale oil will be shipped from Tract C-a by tank truck. Retort water will be pumped to a sour water surge tank and then to a system of lined evaporation ponds.

Gas from the underground separator will be drawn through an off-gas shaft to the treatment plant gas/water knockout drum by the low BTU gas booster compressor. This unit will control the pressure drawdown across the retort and force off-gas through the treatment plant incinerator/scrubber. The incinerator (Figure 55) will convert virtually all sulfur gases to sulfur dioxide, which will be washed out of the gas stream by contact with a soda ash/recirculated sodium sulfite solution in a scrubber unit. The scrubber is designed to remove better than 90 percent of the sulfur dioxide from the incinerator flue gas before it is emitted to the atmosphere. The stack gas will be monitored for total gas, SO_2 concentration, and opacity to comply with emission permit requirements. During commercial operation, the raw flue gas will be used to generate power and process steam.

Retort startup off-gas and gas flow during upset conditions will be flared (Figure 56) instead of being sent to the incinerator/scrubber units. A natural gas pilot flame will be used to burn the flare at all times.

Figure 57 depicts anticipated shale oil production from Tracts C-a and C-b beginning with test retorts through commercial operation.

Waste Water

To date, most of the waste water generated on-tract has been derived from mine dewatering and treated sewage effluent. Mine seepage water at Tract C-a is pumped into a retention pond to permit settling of suspended solids and to clarify the grayish appearance apparently related to unoxidized H_2S. The water is then either injected into upper aquifer wells peripheral to the mine development area or discharged to Corral Gulch under NPDES permit. During 1979, 1800 acre-feet ($2.2 \times 10^6 m^3$) were reinjected and nearly 4,000 acre-feet ($5 \times 10^6 m^3$) were discharged to surface drainages. Sewage and gray water are treated in an on-site plant (aerated, clarified, and chlorinated) before being pumped to the retention pond to become part of the reinjection stream. Four lined evaporation ponds have been built to handle waste water from the retort off-gas scrubber, retort sour water, and other process sources. Additional ponds may be built.

On Tract C-b, the waste water system for mine water consists of three unlined five acre-foot ($1.8 \times 10^4 m^3$) capacity ponds. Two ponds (A and B) are used for settling suspended material in mine seepage water and for adjusting the pH by addition of H_2SO_4. During 1979, all treated water was either used on-site for construction purposes or discharged to the east fork of No-Name Gulch (a tributary to Piceance Creek) under applicable NPDES permit. Nearly 110 acre-feet ($1.4 \times 10^5 m^3$) of water were handled in this manner. In the near future, a portion of the treated

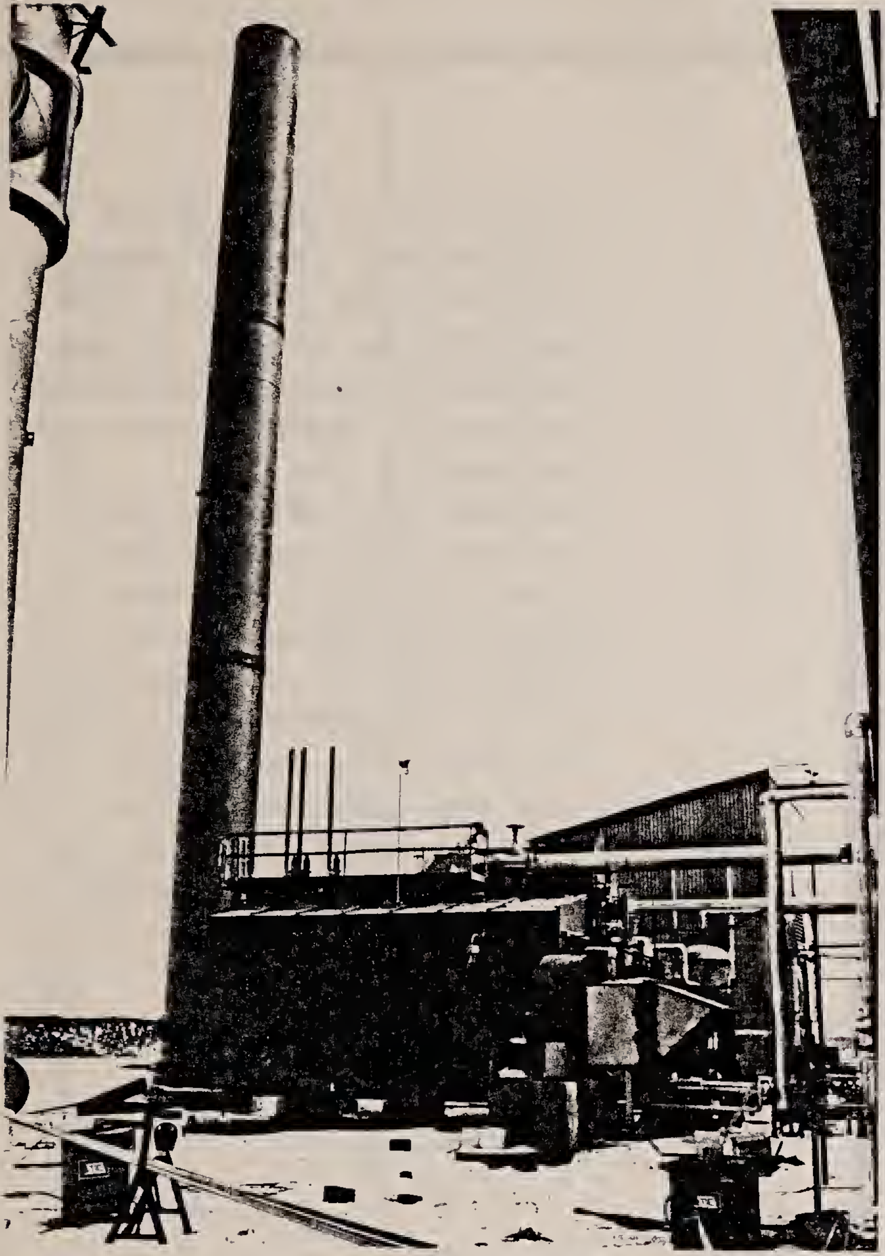


Figure 53.— Photograph of the 65,000 lbs/hr (3×10^4 kg/hr), 120 psi (8 kg/cm^2) steam generator at the Tract C-a retort off-gas treatment plant. Steam will be provided for use in the gas treatment and oil recovery facility, and for injection together with air into MDP in-situ retorts to control flame front temperature and burn rate. Boiler flue gas will vent through the 100-foot (30 m) stack.

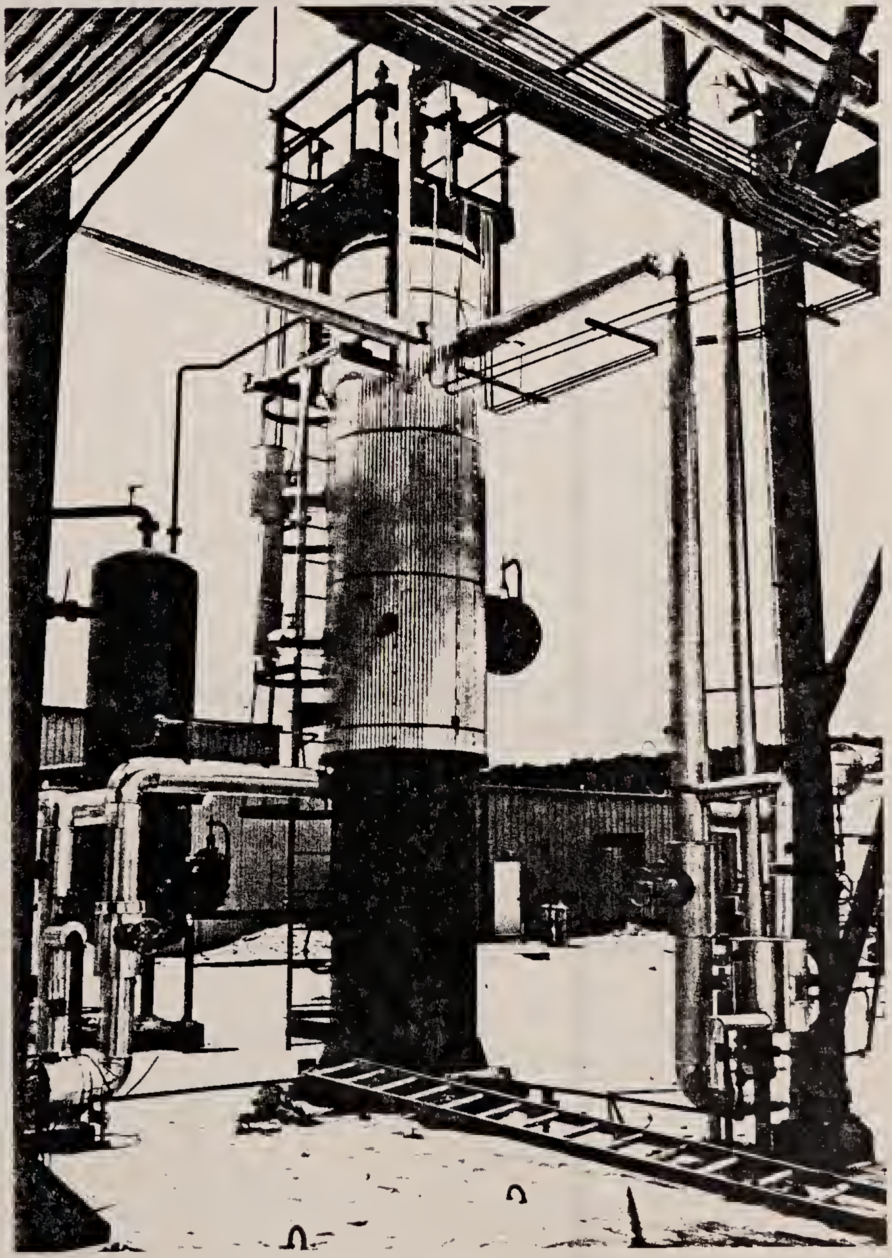


Figure 54.— Photograph of the C-a MDP retort raw oil pre-flash separator drum. Product oil and gas will be separated in a unit located underground. Raw shale oil will then be pumped to the surface and through this pre-flash drum to remove any remaining gas. Product oil will then be cooled and pumped to storage tanks.

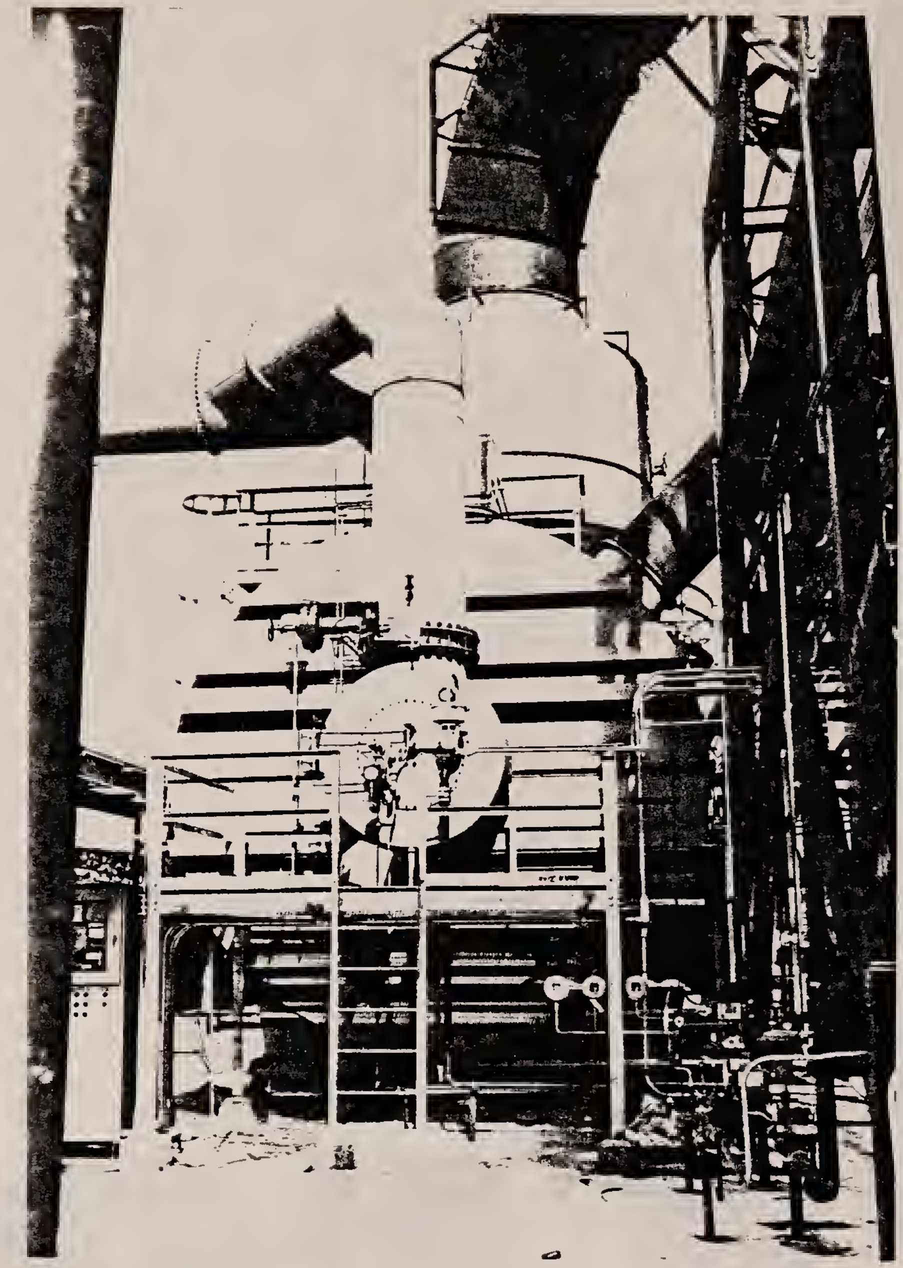


Figure 55 -- Photograph of the C-a MDP retort off-gas incinerator. Retort off-gas will be pulled to the surface through a knockout system to remove entrained moisture. The gas stream will then be fed to this incinerator and quench tower to convert all sulfur gases to SO_2, which will be scrubbed out (90 percent efficiency) by contact with a soda ash and recycled sodium sulfite solution, and vented to the atmosphere through a 200-foot (60 m) stack.

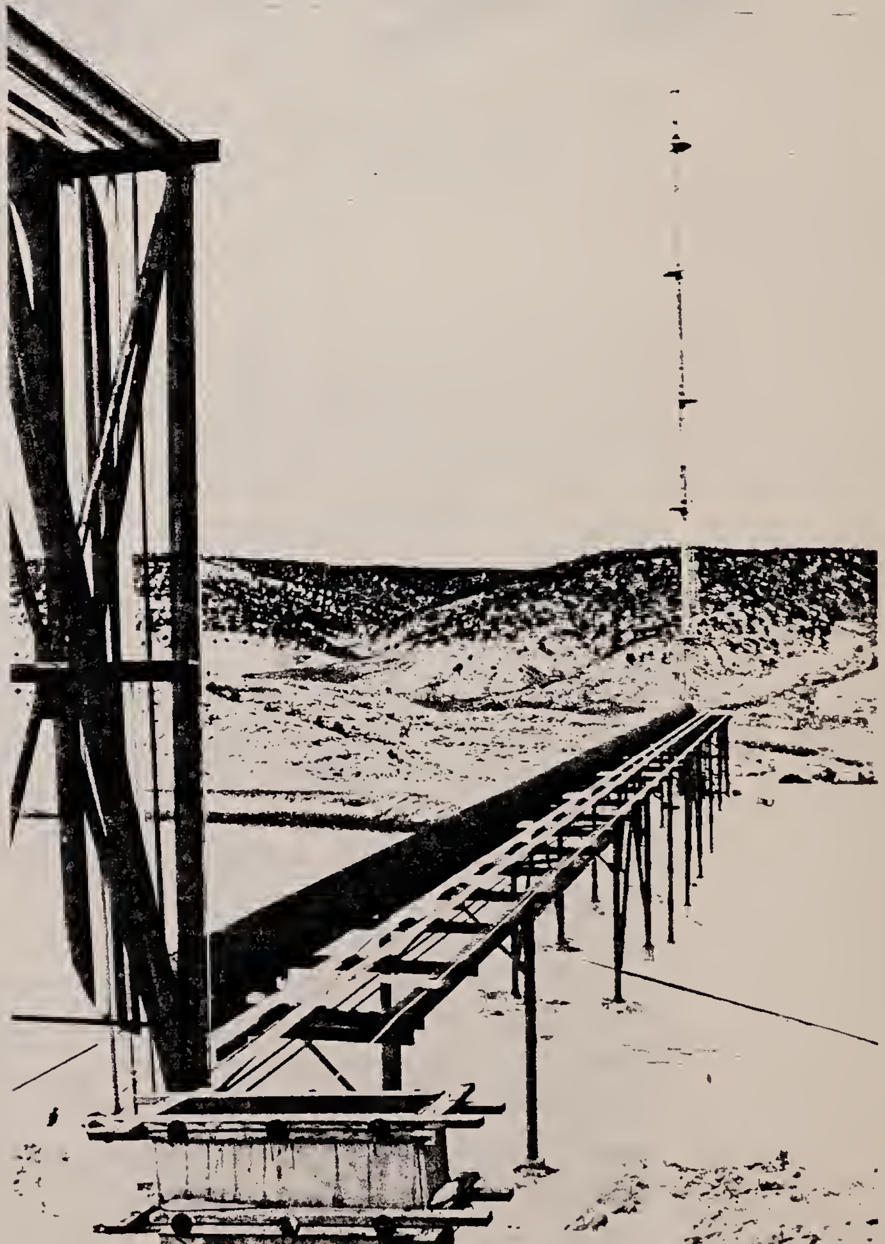


Figure 56 -- Photograph of C-a MDP retort off-gas flare stack. During periods of retort start-up and upset conditions, retort off-gas will be diverted to this natural-gas-fired flare stack.

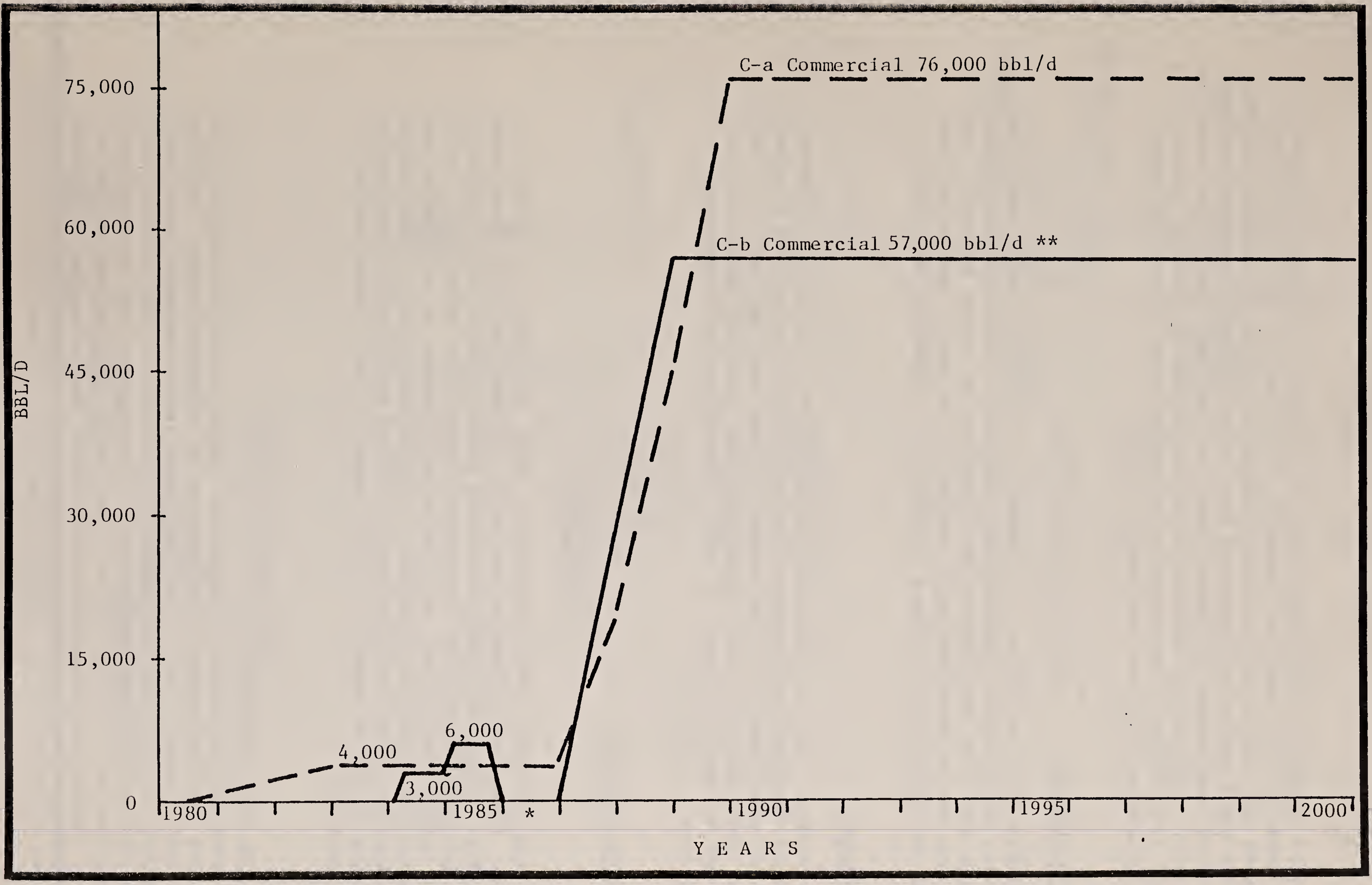


Figure 57. -- Graphic depiction of anticipated shale oil production from Tracts C-a and C-b

* Tract C-b will have no production during 1986, while commercial in situ retorts are being prepared. Production during 1984 and 1985 are from test retorts.

** Lessees of tract C-b are considering a revision to their Detailed Development Plan that would increase commercial production rate from 57,000 bbl/d to nearly 125,000 bbl/d by 1990.

water will either be reinjected after filtration or applied to undisturbed areas of the tract by a network of irrigation sprinklers. The third pond (C) will be used as surge storage for these two systems (Figure 58). The small amount of sewage and gray water currently produced on-tract is collected and trucked to nearby community treatment plants by a commercial contractor. Wastes from administration buildings are handled by an adjacent leach field. The lessee is currently seeking bids for design and construction of an on-tract sewage plant.

Spill Contingency

Both tracts have facilities for storage of fuels, lubricants, and other chemicals. All storage locations have been diked consistent with industry practices and lease requirements for the amount of stored material. Each tract also has an emergency spill response plan and a designated team trained in control and cleanup of spills of hazardous materials.

Solid Wastes

At the present time, a commercial disposal service is hauling construction waste materials and garbage from both Tracts C-a and C-b to county land fill sites near Rifle and Meeker. Scrap metal and waste oil are sold to local dealers. Scrap wood and large slash are taken off-tract under BLM firewood permits. It will eventually become necessary to develop on-site landfills.

Overburden Handling

Clearing

Before any on-tract area is disturbed, trees and brush are carefully removed. Merchantable wood is cut up for firewood and distributed under BLM permit. Brush and slash are either scattered back into undisturbed areas for wildlife habitat improvement, raked into windrows to form erosion control brush dams, or chipped and broadcast as an erosion control mulch and organic soil builder. Limited open burning under applicable permit has been used when slash is of no value and back-scattering unfeasible or of no benefit, or when stands to be cleared are badly insect infested.

Soil and Rock Storage

Before construction begins, topsoil and usable subsoil are stripped and stockpiled for future use in reclamation of disturbed areas. To date, 50,000 cubic yards ($3.8 \times 10^4 m^3$) of topsoil-like material have been stockpiled. In the arid environment of the tracts, this material is a limited and valuable resource, as well as a necessary one for reclamation. All long-term soil storage piles (40-60 years) are benched, compacted, properly sloped, and revegetated for erosion control and wildlife use.

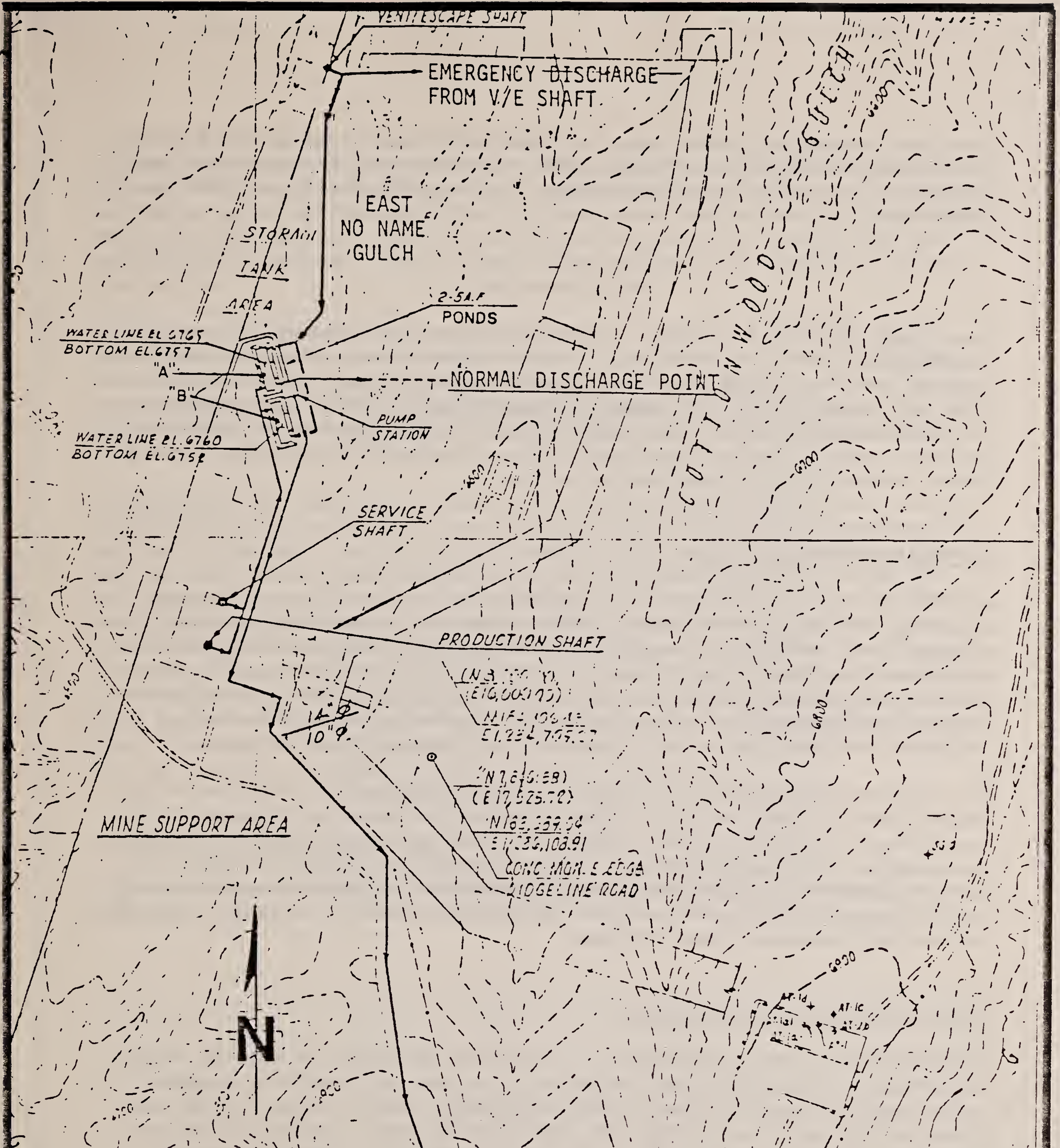


Figure 58. — Plot map of waste water handling system on Tract C-b

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

Rock and overburden, other than oil shale, is used first to fill and shape operational areas. Excess spoil is placed in prepared areas and contoured, topsoiled, and revegetated for erosion control and habitat management.

Mine Waste Rock

Mine waste rock will be used to construct dams, impoundments, and for construction fill. Thereafter, it will be permanently disposed of in gulches on-tract which have been fore-stripped of soil-like material. This soil material will be used to blanket waste rock piles preparatory to revegetation. Mine waste rock contains little if any oil shale of economic grade. Raw oil shale will be stockpiled in a way that permits future recovery for aboveground retorting.

Raw and Retorted Oil Shale

At this point in development, no significant amounts of raw, economic grade oil shale has been mined. Some run-of-mine material from shaft sinking does contain oil shale, but, in general, this material can be considered as overburden or waste rock, and used for process area development, dam construction, and construction fill. Oil shale mined during retort development will be evaluated for leachable substances before a decision is made to permit its use for construction purposes.

No retorted or processed oil shale is being produced at this time on the leased tracts. Before it is, provision will be made for disposal pile development, erosion control, toxic material containment (if any), and revegetation of disposal sites. As an alternative disposal method, it may be possible to slurry reinject or mechanically backfill a portion of the aboveground retorted shale into the rubble chambers of burned out MIS retorts and abandoned mine workings.

Erosion Control and Reclamation

Erosion control and reclamation of disturbed areas is an ongoing lease requirement. Both Colorado tracts use a network of diversion ditches to route runoff around and away from development areas. Runoff from construction sites is collected and channeled through a system of 100-year design storm settling basins prior to discharge to local drainages. Scarification, revegetation, slope reduction, and other physical methods are used to limit erosive effects. Wetting and application of soil sealers and dust palliatives are used during dry seasons to control dust generation. To date, the most significant increase in erosion has been associated with channel scouring caused by discharge of treated mine water into the normally dry streambeds of on-tract gulches.

The most effective method developed to date for reclamation of construction areas, drill sites, and for future raw and processed oil shale deposited on the surface is the return of soil and soil-like material bladed from disposal areas prior to use. This provides suitable bedding material for rapid establishment of seeded grasses, forbes, and shrubs. A limited amount of transplanting of young trees and shrubs has been tied with marginal success. All areas with three years of growth time have established apparently stable cover crops suitable for return to range grazing use.

For disturbed areas of soil stock piles and raw and processed shale, experiments with various bedding preparations, seed mixtures of native and introduced vegetative species, time of seeding, mulching, fertilizing and possibly short-term supplemental irrigation are being carried out in accord with lease requirements to prove reclamation methodology within 10 years following DDP approval.

Revegetation of the large volumes of raw and processed shale that will be generated during commercial operation of Tracts C-a and C-b presents an untried situation. Revegetation, however, has been successfully carried out on small-scale experimental plots by the lessees and by other oil shale companies and research organizations. Present information indicates that revegetation can be accomplished on these drastically disturbed areas using special management procedures such as irrigation, leaching of root zone areas, resoiling with 12-18 inches or more of soil-like material, fertilizing, and mulching (Figure 59). In the case of processed shale, ways must also be found to mitigate the dark color and high solar heating that will inhibit seed germination if revegetation is attempted directly on the retorted material.

Area Disturbed and Reclaimed

Table 8, summarizes areal extent of major surface disturbance and reclamation by year end 1979 as reported by the lessees of Tract C-a and C-b.

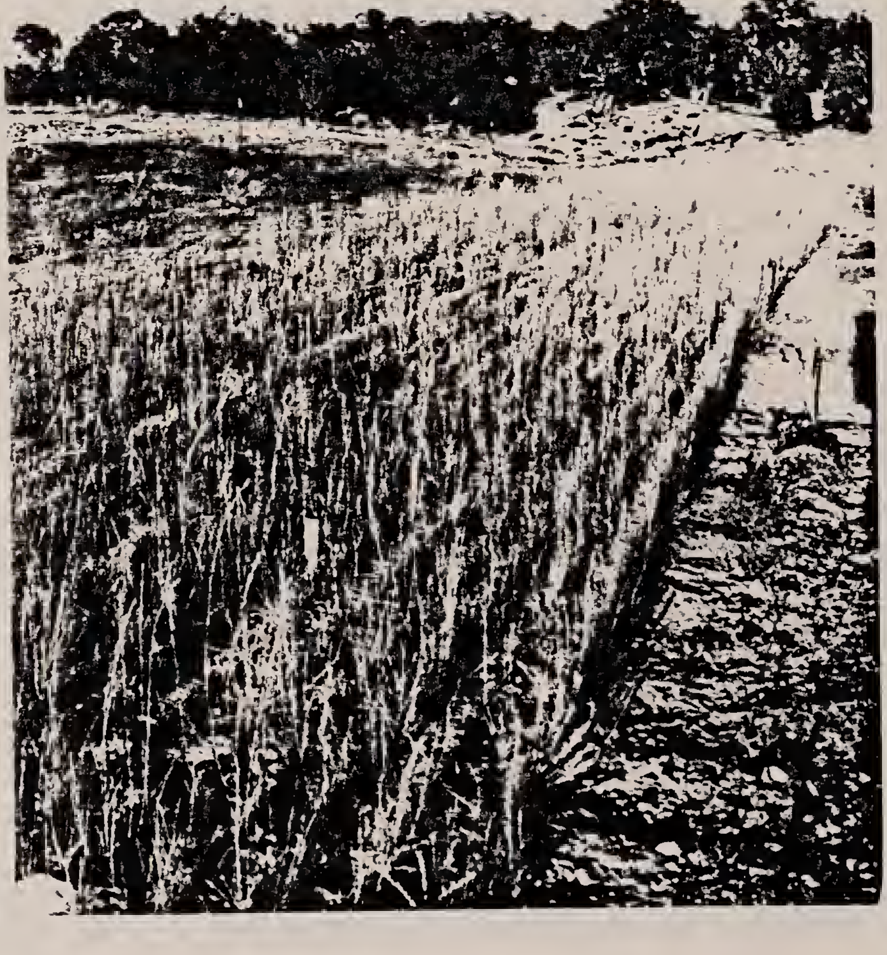


Figure 59. — Photograph of revegetation study area near Tract C-a. The lessees now presently monitoring revegetation success, plant vigor, and plant community composition on three revegetation sites. Two companion plots are on opposite north and south facing slopes. A third site was established with a layer of processed shale under a soil cover of native material to determine the effect of potential leachate on revegetation success.

Table 8. -- Disturbance and Reclamation Through 1979
(All values rounded to nearest whole number)

Affected area	Tract C-a Disturbed	Tract C-a Reclaimed	Tract C-b Disturbed	Tract C-b Reclaimed
Mine support area	52	24^{M}	101	30^{M}
Access/utilities	17	22^{M}	17	11^{P}
Explosive storage	1	1^{M}	1	1^{M}
Impoundments or land application	24	16^{T}	30	4^{P} 26^{M}
Borrow areas	15	7^{T}	3	3^{P}
Soil and rock stockpiles	7	4^{P}	12	9^{P}
Mined material disposal	13	10^{M}	6	1^{M}
Monitoring facilities	1	1^{T}	1	1^{M}
Reinjection	26	7^{P}	5	5^{M}
Total	156	92	176	91

M = Mechanically stabilized
P = Permanently reclaimed
T = Temporarily reclaimed

Areas disturbed for permanent facilities, such as roads, mine development, plant sites, and impoundments will not be permanently reclaimed until tract operations are terminated which may be as much as 50 years from now. Other areas including topsoil and overburden stockpiles, drill pad sites, utility corridors, and abandoned road sections have been permanently or temporarily reclaimed by reshaping, scarifying, topsoiling, back scattering of slash, and seeding to approved plant species.

Reclaimed areas are evaluated annually to determine reclamation success. These evaluations have shown that in addition to seeded species, natural plant succession and native plant invasion from surrounding areas are taking place. Topsoil and overburden stockpiles have been sloped, seeded, and mulched, but not yet evaluated for vegetative success due to the short time they have been in existence (generally less than two growing seasons).

Major Permits Obtained

Lease terms require that lessees comply with all applicable Federal, State, and local regulations. This includes acquisition of necessary permits, notices, and certifications appropriate to the nature of development and operations. A survey by the AOSO suggests that some 100 different types of permits, involving more than 20 separate agencies, in addition to development and monitoring plans that must be approved by the USGS Area Oil Shale Mining Supervisor would be required to bring a Federal lease tract in Colorado to commercial production. Table 9 lists the major types of permits and plan approvals obtained by the lessees to date. Agency abbreviations are defined at the end of the table.

Table 9. -- Inventory of major permits and plan approvals obtained by year end 1979

Permit	Agency	Description
	Air	
Prevention of significant deterioration (PSD)	EPA/State	To prevent significant deterioration of background air quality from new facilities
Emission permit	CAPCD	To construct and operate facilities that will emit to the atmosphere
Fugitive dust	CAPCD	To construct or operate dust generating activities
Open burning	CAPCD	To burn any waste, debris, slash, etc
	Water	
National pollution discharge elimination system (NPDES)	CWQCD	For surface discharge of water
Spill prevention and control	EPA/Coast Guard/ CWQCD	Oil spill prevention and countermeasure plan
Water well	BLM	To construct water well on Public Land
Well permit	CSE	To drill and operate water well
Dam construction	RBC/CSE/USBM	To construct reservoirs
Reinjection	EPA/CWQCD/CDH	To reinject excess mine water
Subsurface disposal	CWQCD	To place waste underground
Water pipeline Water rights Water storage Water augmentation	CWC/RBC/CSE	To develop, transport, use, store, and replace surface and ground water

Permit	Agency	Description
White River option	CWC	For diversion and storage of water from White River
Waste water treatment	CDH	For operators of water treatment facilities
Sewage disposal	CWQCD	To operate sewage treatment plant
Dredge and fill	Corps Eng/EPA/CWQCD	To dredge or fill in streams
Stream crossing	Corps Eng/EPA/CWQCD	To bridge a stream
	Land	
Historic preservation	DOI/CHS	Clearance of disturbance sites of historic/cultural values
Federal lease	BLM/USGS	To develop Federal Oil Shale deposits
Temporary or special use	BLM	For facilities located on public land off-tract
Prospecting/ activity	BLM/CMLRD/CDM/MSHA	To evaluate and develop access to oil shale
Rights-of-way	BLM	For access, utilities, and communication off-tract
Radio license	FCC	To operate telecommunications
Mined land reclamation	CMLRD	To disturb the surface
Special use	RBC	Amend county zoning restrictions
Building	RBC	To build any facility
Airfield/heliport	FAA/RBC/BLM	To construct light landing strips or helipad
Tall structures	FAA	To build structures over 200 feet high
Trenching	CDL	To excavate trenches
Mobile home	RBC	To set up trailer camp
Explosives	CDM/CDL	To store and use explosives
Waste disposal	EPA/RBC/CWQCD	To dispose of solid waste and sewage

Permit	Agency	Description
	Mining	
Health and safety	MSHA/CDM	To certify miner safety training
Underground fires	MSHA/CDM	To burn oil shale underground for retorting
Mine notice	MSHA	To commence underground mining
Hoistman cert.	CDM	To certify hoist operators
Hoist speed	CDM	To exceed 800 ft/min. hoist rate
Underground diesel	CDM	To use diesel powered equipment underground
	Other	
Public necessity	CDH	To set up health care facility
Fuel burning installation	DOE	To use fuels other than coal to fire boilers
Food service	CDH	To provide food service on-tract
Development plan	USGS	To develop any facility on lease tract
Monitoring plan	USGS	To carry out environmental monitoring
EIS	DOI	For any major Federal action

DOE: U.S. Department of Energy
EPA: U.S. Environmental Protection Agency
DOI: U.S. Department of Interior
MSHA: U.S. Department of Labor, Mine Safety and Health Administration
BLM: U.S. Department of Interior, Bureau of Land Management
USBM: U.S. Department of Interior, Bureau of Mines
USGS: U.S. Department of Interior, Geological Survey
FAA: Federal Aviation Administration
FCC: Federal Communication Commission
CAPCD: Colorado Air Pollution Control Division
CWQCD: Colorado Water Quality Control Division
CSE: Colorado State Engineer
CDH: Colorado Department of Health
CWC: Colorado Water Court
CDM: Colorado Division of Mines
CHS: Colorado Historical Society (Office of State Archaeologist)
CDL: Colorado Department of Labor
CMLRD: Colorado Mined Land Reclamation Division
RBC: Rio Blanco County
Corps Eng: U.S. Army Corps of Engineers

ENVIRONMENTAL MANAGEMENT AND MONITORING

Monitoring Network

Across each tract and within at least a one mile perimeter, the lessees have laid out a network of biotic and abiotic environmental monitoring stations and transects. In accord with monitoring programs and sampling frequencies approved by the AOSO, each lessee gathers data continuously on air quality, meteorology, and hydrology, and periodically on aquatic and terrestrial wildlife, vegetation production and utilization, and geochemical and geotechnical conditions. Data are also routinely gathered on development progress, health and safety, workforce status, population growth, community impacts, and road utilization. These data are compiled and analyzed by the lessee and reported at least semi-annually together with backup field data to the Area Oil Shale Office. There the data are further analyzed for lease and development plan compliance, impact assessment, and are archived for government and public use.

The following sections of this report summarize monitoring activities and major findings or trends to date. In general, it can be stated that development work on-tract has had no significant adverse effect on the environment, except for: (1) areas that have been directly disturbed by construction; (2) where release of treated mine water is deeply incising normally dry gulches north of both tracts, and apparently killing out an area of sagebrush northeast of Tract C-a due to ground saturation; (3) increased traffic along Piceance Creek Road; (4) areas where revegetation experimentation or habitat augmentation is taking place; and (5) increased population and need for housing and services in surrounding communities.

Hydrology

The two Colorado tracts are located in the Piceance Creek basin, a 900-square mile area of moderate relief drained to the north into the White River by Piceance and Yellow Creeks. Piceance Creek flows perennially throughout most of its course, while Yellow Creek is ephemeral except for a few reaches. Corral Gulch and Stake Springs Draw drain Tract C-a into Yellow Creek; Tract C-b is drained into Piceance Creek via several short ephemeral tributaries and by the more persistent drainages of Willow Creek and Stewart Gulch.

Tracts U-a and U-b are in the northeast part of the Uinta basin, along the south side of the White River. The tracts are drained by Evacuation Creek on the east and by Asphalt Creek on the west, both are major tributaries of the White River. Southam Canyon and several smaller unnamed tributaries drain most of Tract U-a into the White River. Evacuation Creek is perennial across most of Tract U-b, while the other drainages are ephemeral.

Large amounts of ground water (2.5-25 million acre-feet) occur in the Uinta and Green River Formations in the Piceance basin. In general, ground water in these formations occurs in an "upper" and "lower" aquifer system, separated by the rich oil shale of the Mahogany Zone. Ground water also occurs in the alluvium along the major drainages in the basin.

Ground water occurs beneath the Utah tracts in the alluvium along major tributaries, in the Uinta Formation beneath the northern part of the tracts, in the "Birds-Nest" aquifer in the Parachute Creek member of the Green River Formation beneath both tracts, and in the Douglas Creek member of the Green River Formation.

The quantity and quality of surface and ground water are monitored at both Colorado tracts. Flow and quality of surface water is monitored upstream and downstream of the tracts by six stations at Tract C-a and by 14 stations at Tract C-b (Figure 60). Flow, suspended sediment, water temperature, and electrical conductance are measured continuously at most stations; pH, dissolved oxygen, and turbidity are measured continuously at some. Water samples are collected monthly, or on an opportunistic basis in ephemeral streams, for laboratory analyses. More frequent sampling and analyses are done by the lessees on their mine water and waste water streams.

On the Utah tracts, surface and ground waters were monitored during the baseline period at 14 gages and at more than 30 wells. No springs occur on the Utah tracts. Following suspension of the leases in 1977, monitoring was reduced to seven gages and 19 wells.

Flow and water quality of springs and seeps are monitored at six sites on or near Tract C-a and at nine sites about Tract C-b. Ground water levels and quality are monitored at 36 wells at Tract C-a and at 36 wells at Tract C-b (Figure 61). The wells are used to monitor ground water in the alluvium and in the upper and lower aquifers to determine effects of mine dewatering, reinjection, surface discharge, and leakage from impoundments.

Surface Water

At Tract C-a, ephemeral streams drain northeastward into the Yellow Creek system. Corral Gulch and its tributaries drain most of the tract. Natural flow in the gulch near the downstream (east) tract boundary ranged during the baseline period from about 260 to 630 acre-feet (3.2×10^5 to 7.8×10^5 m^3) per year. Since 1978, this flow has been greatly increased by the discharge of several thousand acre-feet of mine water, both to Corral Gulch and to injection wells. Surface water in Corral Gulch prior to mine water discharge generally ranged in total dissolved solids from 600-900 mg/l and the predominant ions were Mg^{++}, Na^{+}, Ca^{+}, HCO_3^{-}, and SO_4^{--}. Mine water discharge has averaged about 900 mg/l dissolved solids, and the predominate ions are Na^{+}, Mg^{++}, HCO_3^{-}, and SO_4^{--}. The concentration of suspended solids during periods of high natural flow typically is several 1,000 mg/l. Suspended solids in mine water discharge has averaged less than 30 mg/l. Release of treated mine water has raised the ground water level in reaches of Corral Gulch immediately east of the tract sufficiently to cause apparent stress on small areas of big sage and the appearance of riparian grass species.

At Tract C-b, several small ephemeral streams drain much of the tract directly into Piceance Creek. Willow Creek and Stewart Gulch, major tributaries of Piceance Creek, drain the west and east sides of the tract. The average annual flow in Piceance Creek below Tract C-b is

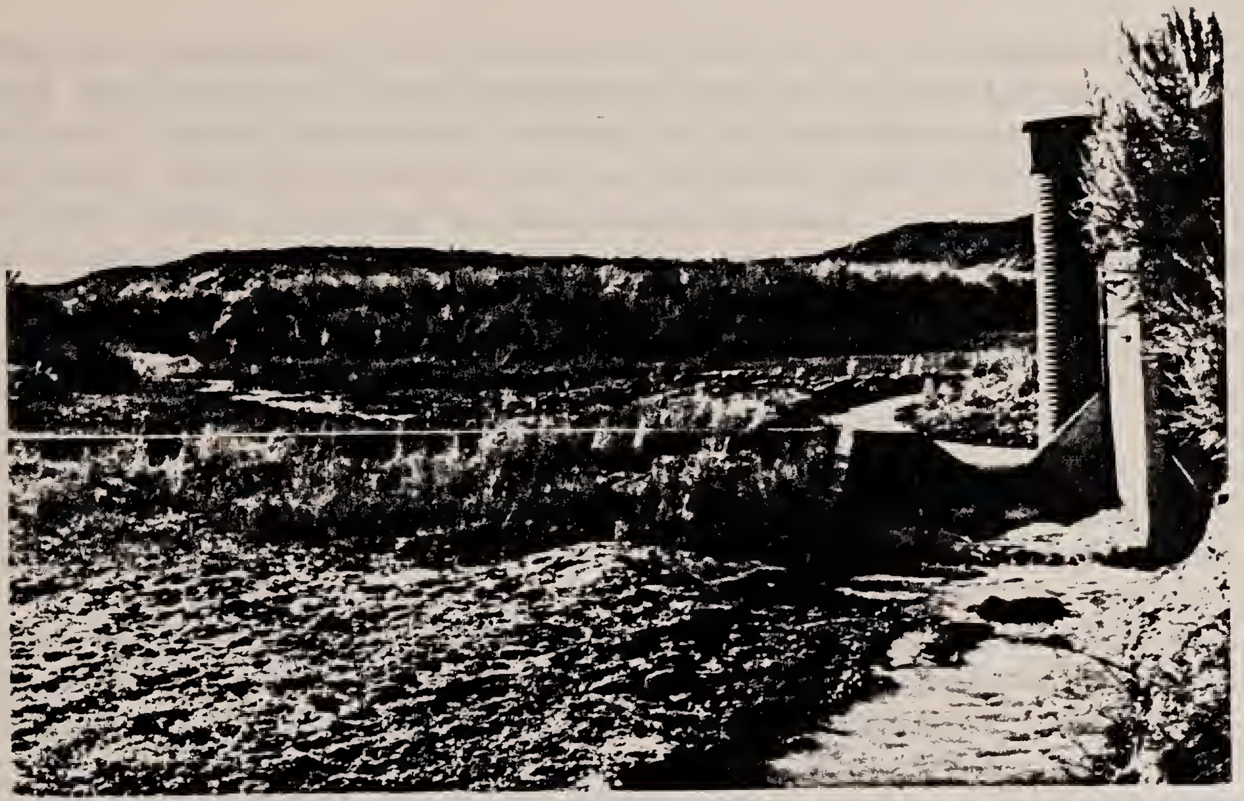


Figure 60. -- Photograph of Corral Gulch surface water gaging station located east of Tract C-a. The "V" notch weir is used to measure low stream flow. A concrete control structure spans the entire drainage channel. Automatic equipment housed in the structure to the right measures flow, temperature, conductivity, and suspended sediment load.

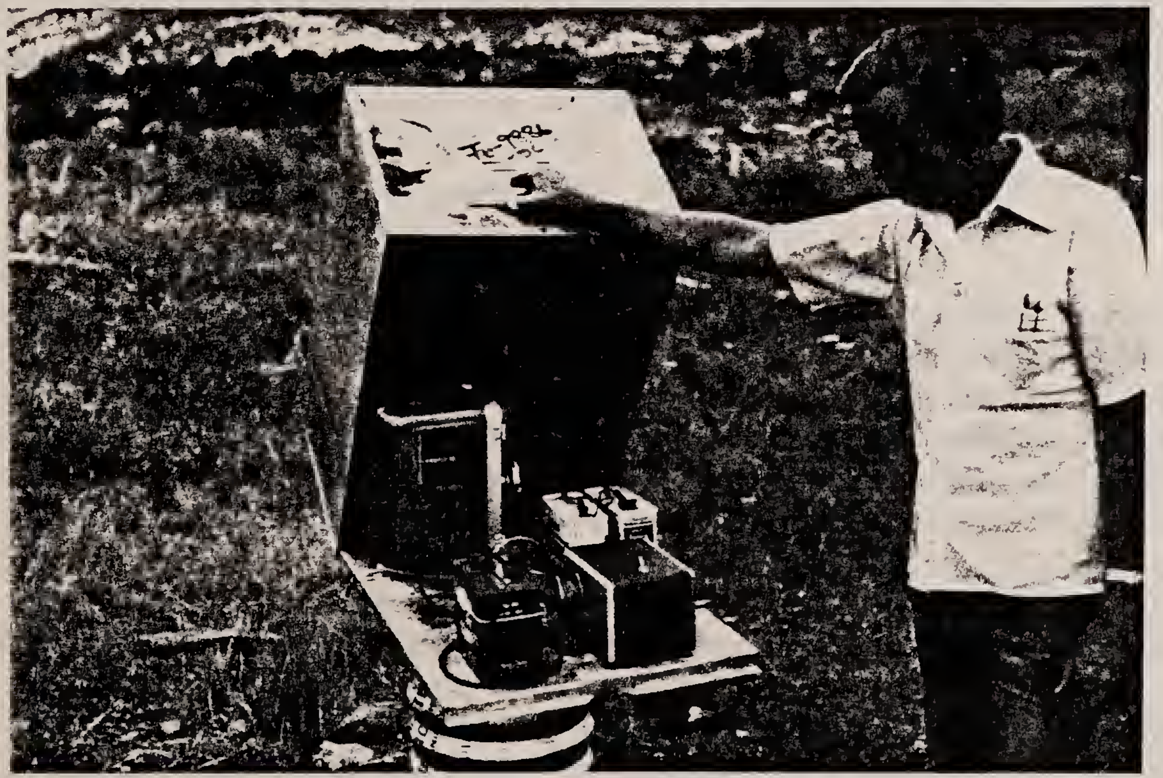


Figure 61. -- Photograph of automatic measuring equipment installed at collar of a deep aquifer monitoring well on Tract C-b. Sensors at end of line actuate reel motor to keep probes just at the top of the water level in the well casing. Punch tape unit records movement of reel line, which is geared to read in water level changes.

about 11,500 acre-feet (1.4×10^7 m^3) for the 1974-79 period. The average annual flow in Willow Creek and in Stewart Gulch is about one tenth of this. Total dissolved solids in Piceance Creek downstream from Tract C-b generally range from 800-1,000 mg/l, and the predominate ions are Na^+, Mg^{++}, HCO_3^{--}, and SO_4^{--}. Suspended solids in Piceance Creek typically average several 10's of mg/l at low flow, and rise to from several hundred to a few thousand mg/l during periods of heavy runoff.

Approximately 90 acre-feet (1×10^5 m^3) of mine water has been discharged from Tract C-b into East No-Name Gulch, a normally dry tributary to Piceance Creek. Less than 10 acre-feet of this discharge reached Piceance Creek by overland flow. The remainder seeped into the normally dry alluvium along the stream channel.

At both Colorado tracts, the mine water discharge has resulted in erosion of sand and gravel in the stream channel, locally as much as a few feet. Deposition of this eroded material has locally filled shallow channels.

Flow in the White River at the Utah tracts averages about half a million acre-feet (6.2×10^8 m^3) per year. The highest flows typically occur during May-July as a result of snowmelt some 90-100 miles (145 to 160 km) to the east on the White River Plateau in Colorado. Local tributaries flow mainly in response to snowmelt and summer thunderstorms.

Water in the White River near U-a and U-b generally contains about 500-600 mg/l dissolved solids during most of the year. This drops to 200-300 mg/l during the spring-summer snowmelt period. The predominate ions are Na^+, Ca^{++}, SO_4^{--} and HCO_3^{--}. Water in Evacuation Creek generally ranges in dissolved solids from about 3,000-5,000 mg/l. The predominate ions are Na^+ and SO_4^{--}. Dissolved solids during flash-flood flow in the normally-dry washes generally ranges from a few hundred to a few thousand mg/l, and the waters are high in Ca^{++} and SO_4^{--}.

Ground Water

At both Colorado tracts, ground water occurs in the Green River Formation, in the Uinta Formation, and in alluvial material along streams. Ground water occurs in joints, fractures, and intergranular spaces in the upper aquifer; in fractures and vuggy zones in the lower aquifer. Prior to mining, ground water at Tract C-a flowed northeast under a gradient of approximately 100 feet/mile (19 m/km). At Tract C-b, the flow is to the north under similar gradient. Ground water in the Green River Formation occurs in an upper and lower aquifer system separated by rich oil shales in the lower part of the Mahogany Zone and in the underlying rich R-6 zone. The degree of hydraulic separation caused by the Mahogany Zone varies considerably over the breadth of the Piceance basin.

Directional permeability appears to be pronounced in the upper aquifer. At Tract C-a, the permeability in a north-northwest direction is estimated to be 5-10 times greater than in a northeast direction, while at Tract C-b permeability in the north-south direction is calculated to be 2-3 times that in the east-west direction. Available data suggests that such anisotropy is not as pronounced in the lower aquifer.

Dewatering operations in the upper aquifer at Tract C-a have locally lowered ground water levels several hundred feet within the immediate mine area. Reinjection of excess mine water peripheral to the Mine Development Area has locally raised ground water levels and hydraulic head from several 10's to several hundred feet in the northern and eastern parts of the tract. The areal pattern of drawdown as shown in Figure 63 is markedly elongated in a north-northwest direction, probably due to several faults of similar trend that act as barriers to ground water movements and thus contribute to the anisotropy.

At Tract C-b, dewatering of the upper aquifer associated with shaft sinking has caused local declines in water level of several 10's of feet in nearby observation wells. The generalized contours of equal drawdown shown in figure 62 for the most part reflect pressure changes in the confined aquifer. Unlike at Tract C-a, where the upper aquifer is being steadily dewatered by pumping from mine workings and from wells, the drawdown at Tract C-b reflects continuous changes in dewatering depth as shaft sinking progresses. As the shafts are deepened, most inflow occurs at the working zone at the bottom of the shaft. Grouting and shaft lining greatly reduce inflows to the shaft above the bottom. Seepage of mine water from treatment ponds and along the East No-Name Gulch (NPDES discharge area) has caused a local rise of from several feet to a several 10's of feet in ground water levels in the Uinta Formation.

Ground water in the upper aquifer at Tract C-a is of $Na^+ - HCO_3^{--} - SO_4^{--}$ type. Na^+ and HCO_3^{--} ions predominate in the lower aquifer waters. Dewatering streams at Tract C-a have been characterized by varying degrees of "black" or "gray" water, presumably associated with H_2S dissolved in the ground water. At Tract C-b, upper aquifer waters are predominately of Na^+ HCO_3^{--} type, and typically range from 800-1,000 mg/l in total dissolved solids. Lower aquifer waters at tract C-b are also of Na^+ HCO_3^{--} type, and total dissolved solids typically are in the 1,000-3,000 mg/l range. Dissolved methane occurs in much of the ground water at both Tracts. On Tract C-b, five aquifer zones have been recognized. The lessee is presently planning to recomplete old wells and drill additional wells to more precisely monitor these separate zones.

Ground water beneath the Utah tracts occurs in sand and gravel deposits of the alluvium, in fractures and intergranular spaces in the sandstones of both the Uinta Formation and the Douglas Creek member of the Green River Formation, and in fractures and vugs in the "Birds-Nest" zone or aquifer in the Green River Formation.

Springs and Seeps

In the vicinity of Tract C-a, more than 30 springs and seeps have been studied, six of these in detail. Tentative evaluation of the data suggests that at least one spring derives its flow from the alluvial aquifer, and four derive at least part of their flow from the upper aquifer. Flows typically range from a fraction of a gallon per minute (gpm) to a few tenths of a cubic foot per second (CFS). Flow at some springs have increased as a result of surface discharge and reinjection of mine water, while flow at others appear to have decreased as a result of mine dewatering. Total dissolved solids in water from springs and seeps at Tract C-a typically

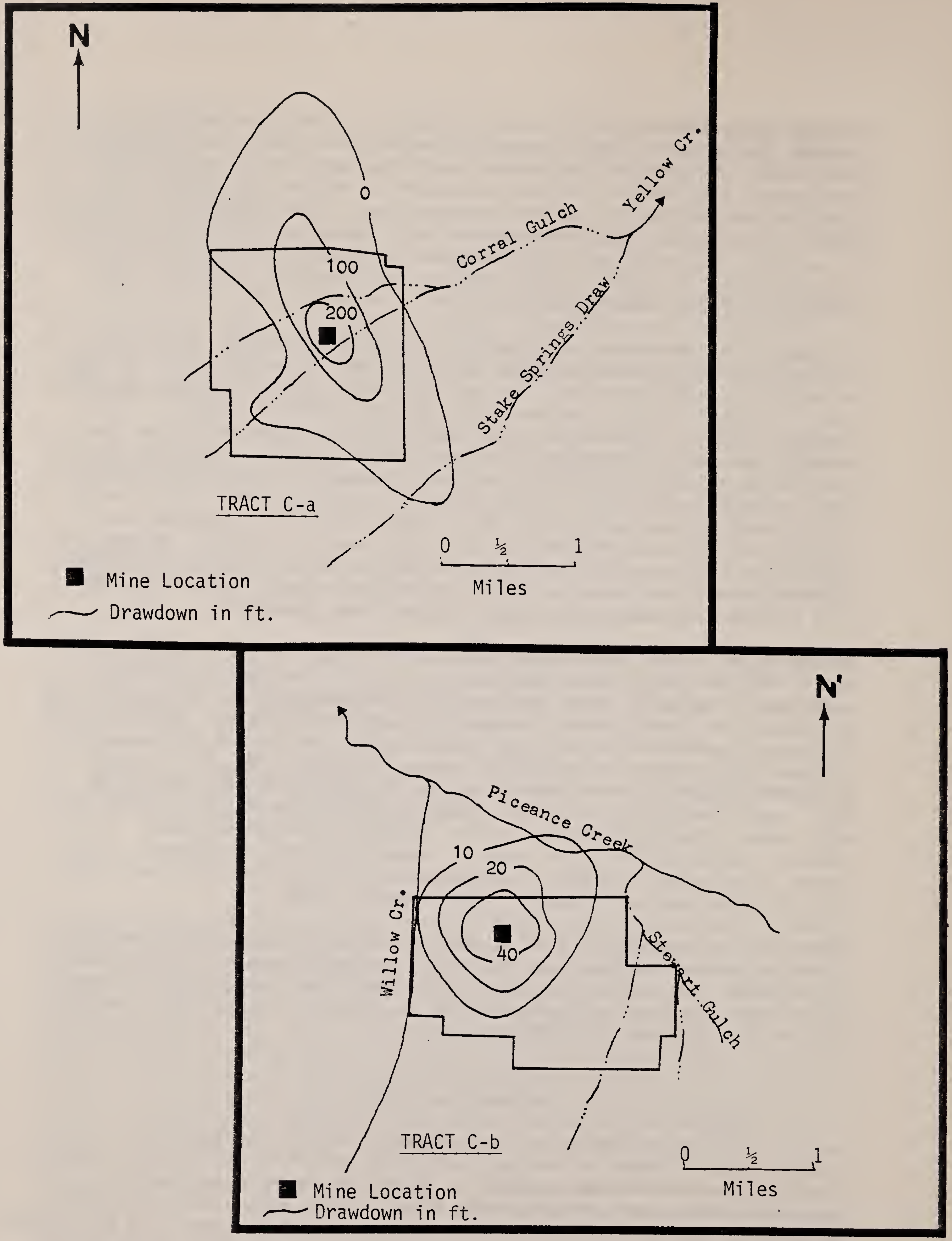


Figure 62.-- Sketch map showing generalized drawdown in upper aquifer due to mine dewatering at Tracts C-a and C-b (as of December 1979)

ranges from about 500-800 mg/l, and most of the waters are of Ca^{++} Mg^{++} Na^{+} HCO_3^{-} type.

At Tract C-b, nine springs and seeps have been studied. Flows in these typically range from a few tenths of a CFS to about three CFS. Total dissolved solids in these waters typically ranges from about 600-1,100 mg/l, and most of the waters are of a Mg^{++} Na^{+} HCO_3^{-} SO_4^{--} type. To date, there are no apparent effects on springs and seeps due to operations on Tract C-b.

Shale Leaching

The Condition of Approval for the monitoring programs at both Colorado tracts require study of the leachability of raw shale disposed of or stored on the surface. Preliminary data from Tract C-a indicate that leachates from raw shale (Mahogany zone and R-6 zone) contain as much as 2,800 mg/l dissolved solids, are of a $CaSO_4$ type, and contain appreciable quantities of several minor and trace constituents that are of environmental concern. Lessees of both Tracts C-a and C-b are developing plans and facilities for raw shale leachate collection and analysis. EPA is cooperating in the analytical phase of the study through a contract with Colorado State University.

Meteorology and Climatology

Climate of the Piceance Creek and Uinta basins is classified as semi-arid steppe, characterized by low relative humidity, low precipitation, abundant sunshine, warm summer temperatures, and cool nights resulting from rapid outgoing terrestrial radiation. Winter temperatures are often low with extremes of -51°F (-46°C) as measured in the Piceance basin. Dry air and intense solar radiation; however, combine to create a generally pleasant climate.

Regional terrain features strongly influences day time temperatures and air drainage patterns resulting in complex surface wind fields dominated by upslope flow during the day (anabatic) and downslope flow at night (katabatic). Features such as local elevation, slope, aspect, soil type, soil moisture, and vegetation strongly influence surface microclimate (wind speed, direction, temperature, etc.).

Meteorology monitoring programs implemented by the lessees have three major objectives:

1. Characterize the meteorology of the area for historical and overall planning purposes;
2. Define meteorological factors which influence transport, diffusion, and chemical changes of pollutants which may be emitted by tract sources; and
3. Provide information for plant design to minimize impacts of future facility operation.

Meteorology monitoring by the lessees began in late 1974 using a central station and several remote monitoring stations. Information collected at remote stations is either radioed to the central station minicomputer, as depicted in figure 63, or is compiled by a minicomputer at each site for manual collection. Meteorological measurements include air temperature, wind speed and direction, humidity, lateral and vertical turbulence, solar radiation, barometric pressure, precipitation, and evaporation (Figure 64).

The five years of meteorology data collected through 1979 are considered baseline because on-tract development activities to date have had little influence on the ambient meteorological conditions. Results of meteorological data analysis indicate:

Precipitation

Precipitation data are collected with weighing bucket gages, tipping bucket gages, and wedge gages. As expected, precipitation (rain and snow) does not occur uniformly either seasonally or regionally over the tracts and surrounding areas. Monthly total differences of 2.1 inches (5.4 cm) have been observed from one gage location to another. Variability is due to terrain influence, differing exposure and gage efficiencies, and natural precipitation variation. On the tracts, annual precipitation ranges from 14 inches (36 cm) to 6 inches (15 cm), with most occurring during summer thunderstorms or as winter snowfall. The maximum recorded precipitation event from a single storm was 1.7 inches 4.3 cm).

Winds

The prevailing wind direction across the Colorado oil shale tracts is from the SSW, and from the ESE over the Utah Tracts. Fall and winter seasons have lower recorded wind speeds than spring and summer. The wind patterns at each site are characteristic of terrain features showing valley channeling effects, i.e., down drainage flow at night and upstream flow during day light hours.

Temperature

Wide temperature extremes occur on the oil shale tracts. Yearly temperature ranges of as much as -51°F (-46°C) to 98°F (37°C) have been recorded. The mean annual temperatures average between 43 and 45°F (6° and 7°C). Low-level temperature inversions have occurred on 75 percent of the nights over the tracts and on 80 percent of the nights above the valley bottoms. Although these inversions usually dissipate by early-to-mid morning, one inversion reportedly lasted 43 hours.

Humidity

Relative humidity (dewpoint) is routinely monitored on the oil shale tracts. The mean annual relative humidity averaged 34 percent on tract C-a, 55 percent on Tract C-b, and 42 percent on the Utah tracts. Pronounced diurnal variation in humidity indicate that the amount of water vapor in the air remains relatively constant day and night.

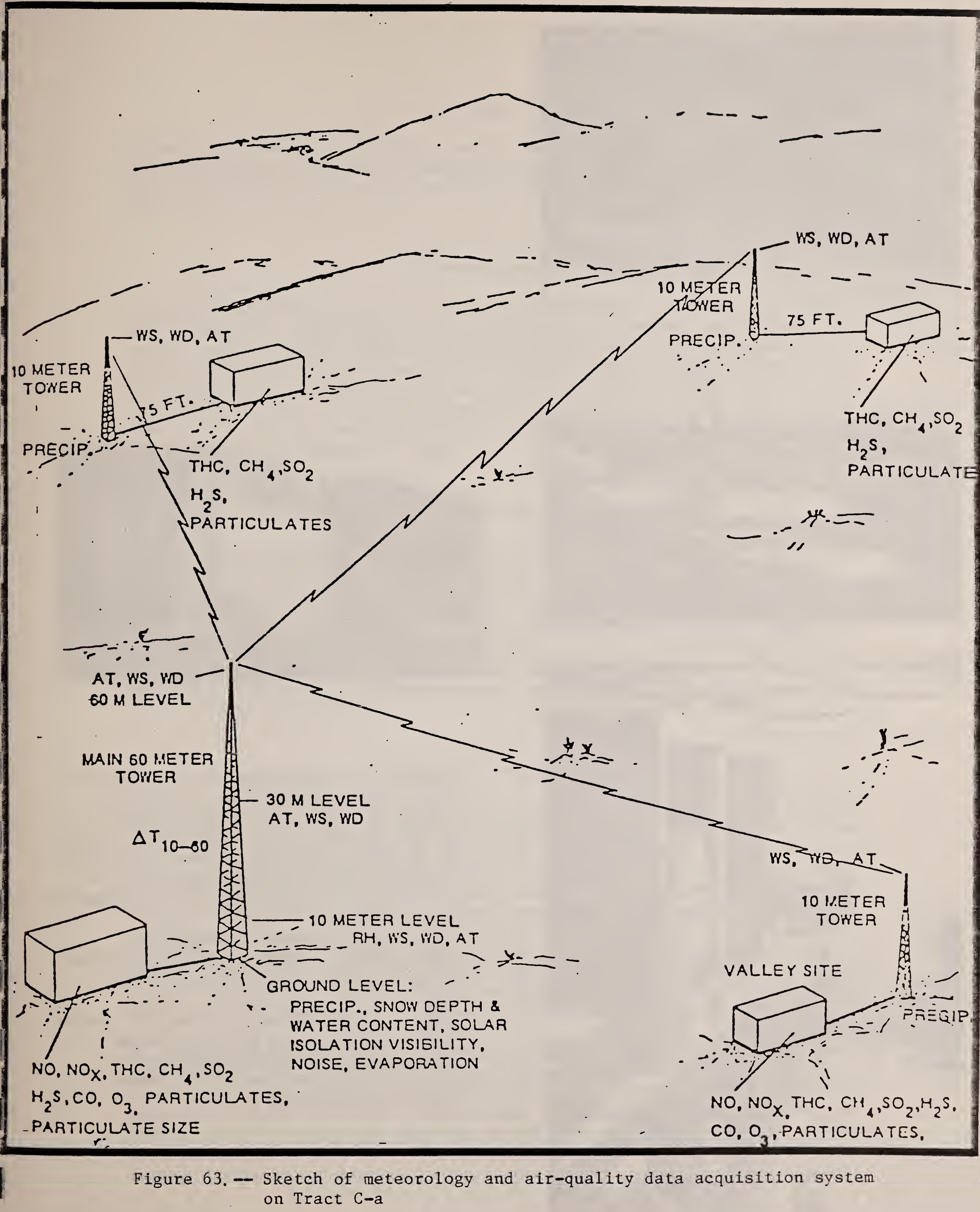
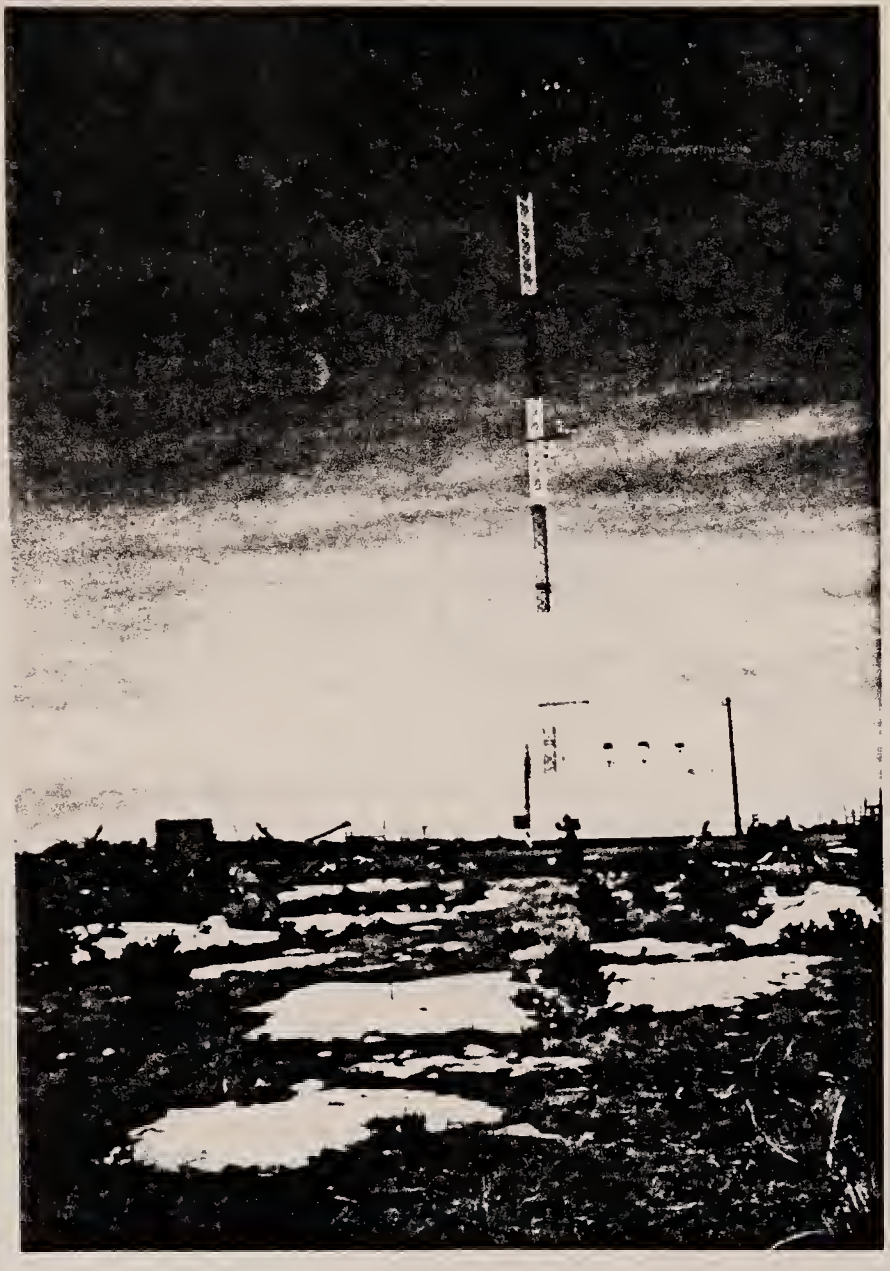
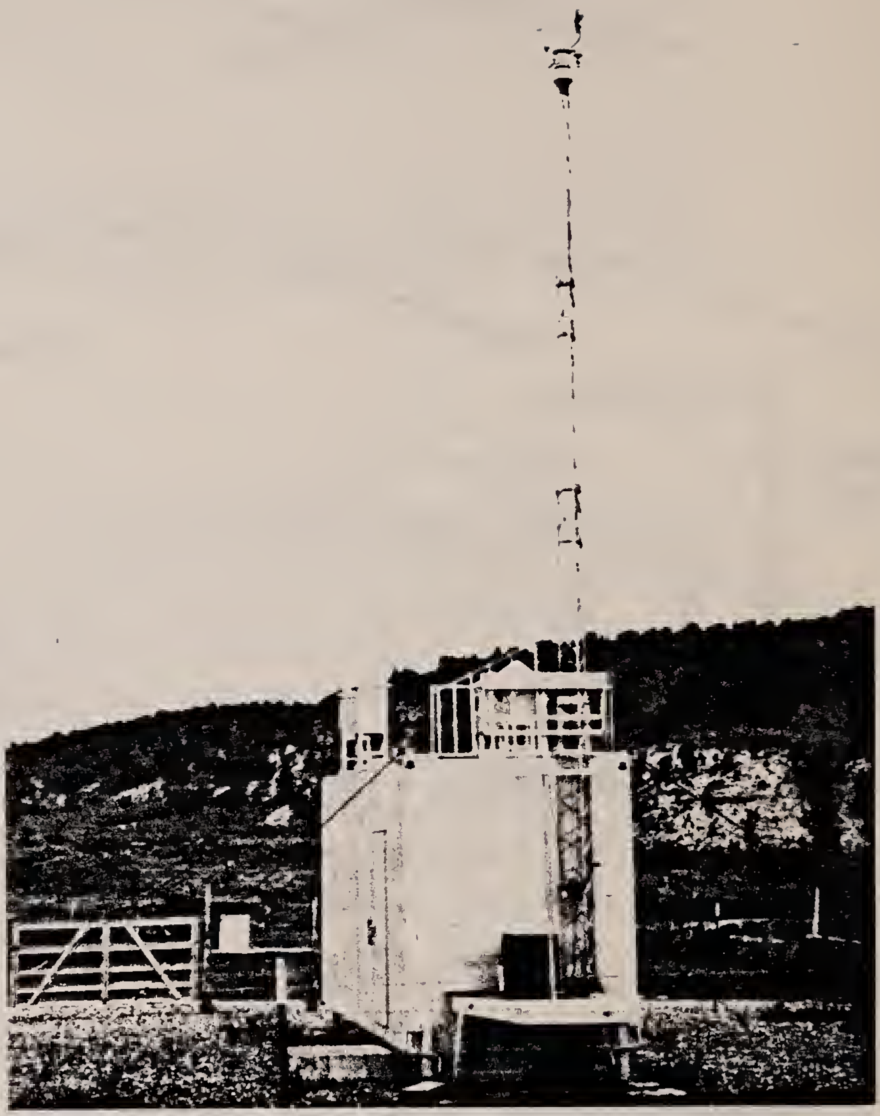


Figure 63. — Sketch of meteorology and air-quality data acquisition system on Tract C-a

From: Rio Blanco Oil Shale Company, 1975.





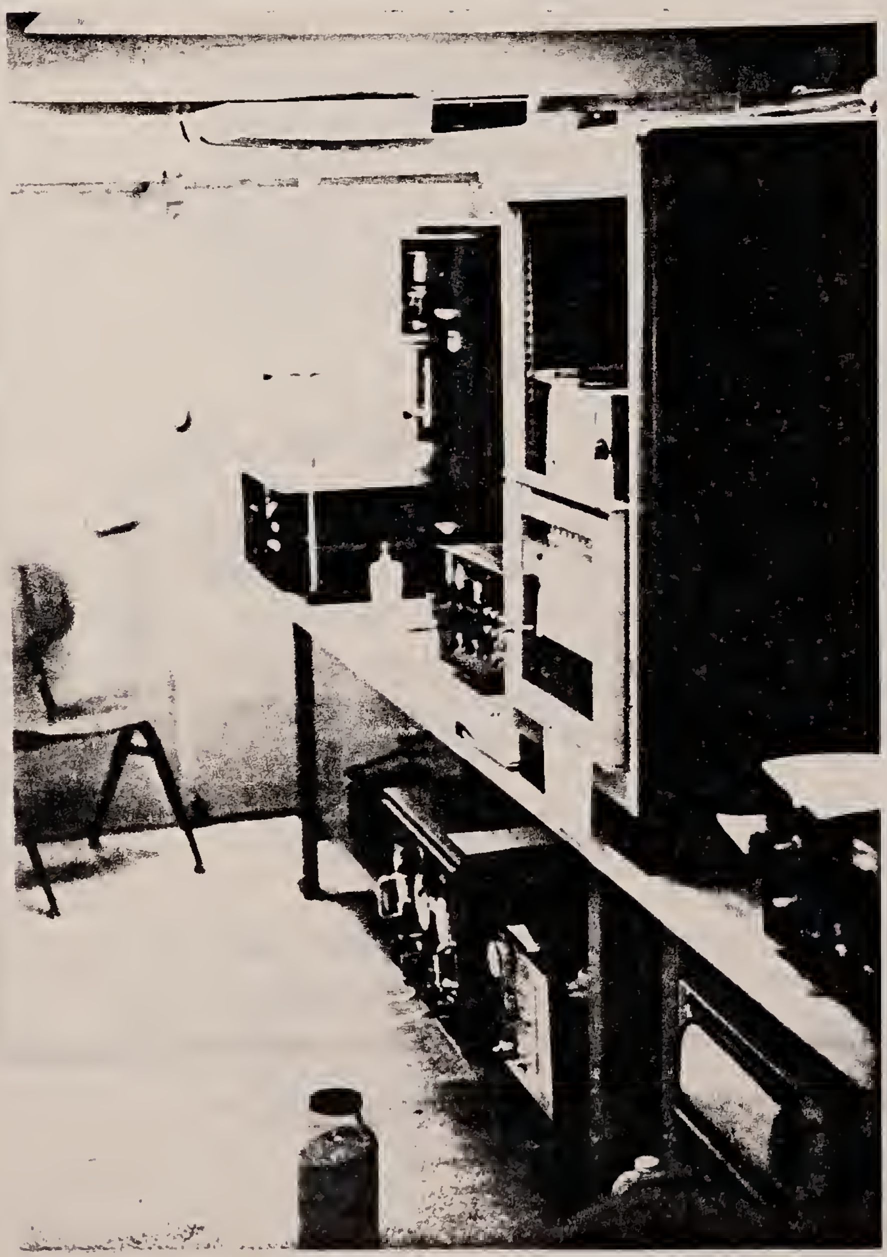


Figure 64. -- Upper Left - This 200-foot (60 m) meteorological tower on Tract C-b is instrumented at three levels to gather meteorological data that is fed to recording equipment housed in trailer. Units on top of trailer gather air for gas and particulate sampling by equipment housed inside.
Upper Right - Remote air-quality/meteorological sampling trailer located along Piceance Creek north of Tract C-b.
Left - Typical air-quality/meteorological sample analysis and data-recording instrumentation housed inside equipment trailers associated with each air quality/meteorology site.

Pressure

Barometric pressure recorded on the oil shale tracts correlated well with synoptic weather patterns influencing the area. The mean annual barometric pressure on Tract C-b averaged 790 millibars (mb) with a high of 804 mb and a low of 753 mb.

Evaporation

Evaporation measurements are routinely made between the months of April and October each year. This timing includes the growing season, but not months when freezing temperatures would have affected measurements. Monthly evaporation totals on the two Colorado tracts ranged from 7.0 to 10.6 inches (17.7 to 27.0 cm) with an average annual evaporation rate of 35 inches (89 cm). On the Utah tracts, monthly evaporation totals ranged from 4.1 to 10.0 inches (10.4 to 25.4 cm) with an average annual evaporation rate of 38 inches (96.5 cm).

Radiation

Direct solar radiation is measured on the oil shale tracts with pyranometers. Maximum solar radiation occurs in June and the minimum in December. On any given day solar radiation is depended on the amount of backscattering or absorption by water vapor, dust and clouds present in the atmosphere. The range of daily readings has been 0 to 741 Langleys. Daily averages ranged from 623 langleys in June to 113 Langleys in December. Net solar radiation is an important factor in evaluating atmospheric stability and photochemical processes as related to emissions from on-tract facilities.

Upper-Air Studies

Upper-air studies were conducted each quarter for a year from the fall of 1974 through the summer of 1975 to obtain information on wind speed, wind direction, and temperatures at altitudes up to 6,000 feet (2,000 meters). These data are being used for plant siting, design, and impact analysis. Upper-air data were collected by specially instrumented aircraft, radiosondes, and pilot balloons. Acoustic sounders were also used to detect temperature inversions and display them in graphic form to a height of 3,000 feet (1 km). Tracer studies were also made to determine the dispersion capability of the atmosphere under varying conditions of stability. Colored smoke was released from a tethered balloon and the motion and decay were monitored both from the ground and from an instrumented aircraft.

To supplement the one year upper-air study, a special 10-day study was made during June and July 1976 again using balloon released tracers. Two overflight points were selected for alternate flights made at two-hour intervals six times a day. Measurements of barometric pressure, temperature, and wind speed were made up to 600 feet (183 km) above the surface. A total of 59 flights were made at selected times to monitor conditions during stable early morning hours, night-to-day transition, and mid-day convection activity. On September 14 and 15, 1978, a study was conducted on Tract C-b to simulate transport and dispersion of emissions from an elevated source in the vicinity of the proposed Ancillary Area retort off-gas processing facility under meteorological conditions conducive to high ground-level pollutant concentrations.

Microenvironmental Program

On Tract C-b, the lessees implemented a microenvironmental program to obtain data useful for planning rehabilitation of areas impacted by construction and disposal of mined material. The program consists of four continuous recording stations that monitor up to six feet (2 m) above the ground for wind speed, wind direction, air temperature, litter temperature, soil temperature, soil moisture, relative humidity, evaporation rate, snow depth, net solar radiation, and precipitation. One station was located in each of the major plant community types on-tract. Seventeen spot check stations were also used to assess microenvironmental differences produced by aspect, exposure, and physical makeup of major plant communities.

Air Quality

The regional air quality of the Piceance and Uinta basins is characteristic of remote areas relatively free of man's influences often referred to as "pristine". Ambient concentrations of sulfur dioxide, hydrogen sulfide, carbon monoxide, non-methane hydrocarbons, and oxides of nitrogen have generally been below the detection limit of available field instrumentation.

Air quality monitoring systems at each tract include a central station and several remote monitoring stations (Figure 63). Information is collected remotely and radioed to the central station minicomputer, or is collected by a minicomputer at each site for preliminary analysis and storage. Air-quality measurements include particulates, sulfur dioxide, hydrogen sulfide, total hydrocarbons, methane, carbon monoxide, ozone, and oxides of nitrogen. Some data are available from the first year of baseline monitoring for concentrations of suspended particulates, trace elements, and gross radioactivity. Only limited data are available for the "volatile" trace elements, mercury, selenium, and arsenic (as arsine), and wet chemical measurements for ambient sulfur dioxide and hydrogen sulfide. Effects of pollutants on visibility were measured by photographic and telephotometric techniques. Noise level data are collected on and in the immediate vicinity of the tract.

The past five years of air quality data collection can be considered largely baseline because there has been little development activity that would have significantly impacted air quality.

Gases

Ambient air concentrations of sulfur dioxide (SO_2), hydrogen sulfide (H_2S), carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO_2), oxides of nitrogen (NO_x), and nonmethane hydrocarbons (NMHC) have generally been below the lower detection limit of instrumentation in use. Ozone, on the other hand, has been on occasion at levels exceeding the former EPA standard of 0.08 ppm. Several studies have been conducted using ozone data in an attempt to explain the cause of high concentrations, diurnal and seasonal trends, and differences between plateau and valley monitoring sites. These studies have failed to yield conclusive results. Transport from distant urban areas, stratospheric transport, and photochemical production from native plant turpenes have all been suggested. At this point, stratospheric transport i.e., out-of-region source, seems to be the favored theory.

During July 1978, EPA personnel spent three days on and in the immediate vicinity of Tract C-b collecting samples for a sophisticated analyses of NMHC. Results of this study failed to substantiate the very high NMHC values which had been recorded by the lessees' monitoring network (available field equipment to monitor NMHC is generally unreliable). EPA concluded that reported high NMHC data do not correlate well with meteorological conditions or with the season, or does it display an inverse relationship to ozone. Biogenic emissions and transport from distant urban areas seem unlikely explanations of this phenomena. The hydrocarbon distribution suggests a heavier than usual presence of paraffins. These could be due to emissions from nearby gas fields. If such were the case, then some correlation should be observed with wind direction or mixing heights. Reported high values could also be due to a malfunctioning hydrocarbon analyzer or, more likely, unintended sampling of ethylene used for the ozone monitor. Ethylene contamination is frequently encountered around such monitors. Due to the uncertainties in NMHC data and analyzer function, measurement of NMHC was discontinued in 1978.

Limited data using wet chemical methods indicate that the background levels on and near the tracts for SO_2 and H_2S approach reported global background levels.

Particulates

Total suspended particulate (TSP) levels have frequently been measured in excess of the National Ambient Air Quality Standard (NAAQS), throughout the five year period since baseline monitoring began. This is not unusual in the arid setting of the tracts and is primarily due to wind blown soil material. Moreover, it is the only air quality parameter on which development operation has had a measurable effect. To control dust generation, the lessees of both Tracts C-a and C-b have established extensive dust control programs including road paving, prompt revegetation of disturbed areas, and the use of water and chemicals to suppress dust on unsurfaced road and construction areas.

Visibility

A one year joint visibility program was conducted by the lessees of Tracts C-a and C-b beginning in the fall of 1975. Photographic/photometric methods were employed for determining the visual range. Since that time, results have been reported for a second and similar joint visibility study conducted during the spring and fall of 1978. No significant change in the mean annual visibility range has been noted since the 1975-1976 measurements. The generalized annual visual range is reported to be 79 miles (127 km). Additional joint studies are being conducted to determine the difference between results from photographic/photometric and telephotometric methods, and the feasibility of long-term use of the latter method.

Modeling

Air quality modeling was performed for each of the tracts. Results of this analysis method indicate that proposed development will meet all applicable NAAQS standards and satisfy existing Prevention of Significant Deterioration (PSD) regulations. Both EPA and the Colorado Air Pollution Control Division have issued all necessary air emission permits for the development phase for Tracts C-a and C-b.

In addition to the modeling analyses, some very limited tracer studies using sulfur hexafluoride have been conducted on Tracts C-a and C-b. These have been used to examine the utility of certain air quality models as applied to oil shale operations. Results of these studies, however, have yet to be applied to any of the development modeling analyses.

Noise

Environmental noise surveys have focused on traffic and construction noise. Noise levels, as would be expected, have increased in the immediate vicinity of development activity. Every sixth day continuous noise measurement conducted on tract C-b, however, indicate no significant increase over background levels in the averaged 12-hour periods from 7:00 p.m. to 7:00 a.m., and 7:00 a.m. to 7:00 p.m. On Tract C-a, it was generally found that background noise levels of 25 dbA were obtained at distances greater than one mile from mining operations. Wildlife disturbance due to noise level of this magnitude is expected to be negligible.

Geology

Oil-Shale Resources

Estimates of oil shale resources on the lease tracts were defined by a total of 23 nomination and 47 exploration coreholes. Six of the exploration coreholes were slant-drilled to provide data on density and orientation of fracturing and jointing with depth. Aggregate depth of all coreholes was nearly 102,000 feet (31,110 m), with a total cored interval of about 65,600 feet (20,000 m). Oil shale assays were completed on about 50,600 feet (15,400 m) of the core. Analyses for nahcolite, extractable alumina, and for trace concentrations of antimony, arsenic, boron, cadmium, fluorine, mercury, molybdenum, selenium and vanadium were also performed on selected core intervals. No strong correlations between trace element concentrations and depth or stratigraphic zone were indicated.

The detailed geologic exploration program conducted by the lessees more fully defined the oil shale resources of the lease tracts. The entire oil-shale interval underlying Tract C-a contains about 9 billion barrels of shale oil and beneath Tract C-b about 13 billion barrels. Total resource for Tracts U-a and U-b, within the vicinity of the Mahogany Zone only, is 1.3 billion barrels. The lease tracts also contain a total of about 30 million tons of nahcolite and about 249 million tons of extractable alumina (dawsonite) at depths generally below the horizon defined for initial oil shale development.

Mapping

Surface geologic mapping and core drilling programs on each lease tract defined the location and extent of faults, joints, and fractures. Shaft sinking and mine development has confirmed that these NW-NE steeply dipping structures extend to depth and directly influence mine water inflow rates. Locally, "bad ground" and overbreak areas, due to jointing and fracturing, have been encountered during underground development. The extent of this jointing and fracturing, and resulting lowering of rock strength was one of the geotechnical reasons for the temporary suspension of operations on Tract C-b and the modification of the DDP from an underground room-and-pillar mine with surface retorting to a modified in-situ operation.

Gas

Presence of methane (CH_4) and hydrogen sulfide (H_2S) gas in the oil shale formation was also indicated during core drilling. These gases have been detected during shaft sinking and mine development. Data indicates that methane gas is first encountered near the top of the oil shale zone and gradually increases in concentration with depth. Concentrations of H_2S appear to be related to increased ground water inflow during mining. There also appears to be some stratigraphic correlation with methane concentrations near the top of the R-5 oil shale zone. Monitoring of gas concentrations in the mine atmosphere is being required by the AOSS.

A core gas sampling procedure developed by the U.S. Bureau of Mines for coal has been used to identify gassy zones in oil shale. Although the method has not been universally adopted for oil shale it definitely shows promise as a predictive tool.

Subsidence

Subsidence monuments have been installed on Tract C-a and will be installed on Tract C-b prior to lateral mine development. These monuments will be used to monitor any effect on land surface elevation caused by dewatering and mining activities. No surface movement has occurred from underground activities on Tract C-a to date. Some alluvial cracks have opened up along drainages on Tract C-a. They are probably related to the effects of natural wet and dry periods rather than dewatering for mine development as similar ground cracks were reportedly observed in the area prior to leasing.

Biology

Flora

The Colorado tracts are located within a pinyon-juniper ecosystem which includes sagebrush, grasslands, and mountain shrub/grassland vegetation types. Herbaceous forage productivity ranges between 200-500 lbs per acre (36-92 kg/ha).

The Utah tracts lie mostly within the desert shrub ecosystem with some gradation into pinyon-juniper. The vegetative community is dominated by small shrubs including salt desert shrub and sagebrush with a thin scattered overstory of juniper trees. Where the White River skirts the northern edge of the tracts, there is a pronounced riparian-to-river bottom habitat. Herbaceous forage productivity ranges from 25-275 lbs per acre (4-51 kg/ha).

Monitoring of vegetative species composition, density, and cover has produced data consistent with that from literature review which indicates essentially static conditions since the beginning of the baseline programs. Development work has had no discernible impacts on vegetative composition, cover, or productivity, except within areas intentionally cleared for construction. Several hundred acres on Tract C-b have been aerially fertilized to enhance forage production to offset habitat lost to construction. On two sites north of the tract, generally unpalatable stands of sage have been destroyed by brush beating and the chopped areas reseeded to establish grazable grasses, forbs, and shrubs to draw deer away from the county road. Several acres of big sage (Artemisia tridentata) northeast of Tract C-a is showing signs of severe stress probably due to near surface ground saturation from mine water discharge. Loss of this sage stand is considered insignificant due to the abundance of similar surrounding habitat, unpalatable quality of the sage due to essential oil content, and the probability that more grazable species common to irrigated bottom lands will take over.

Monitoring of forage production (Figure 65) shows a stable and consistent yearly variation of 200-500 lbs/acre on the Colorado tracts. This variation is apparently due to changes in annual growing conditions. The Utah tracts show an even wider variation between years due to even more marginal growing conditions and extremes in precipitation. For example, Table 9 shows the extremes of forage production recorded during consecutive years of baseline monitoring for the four major vegetation types on the Utah tracts.

Table 10. -- Range of average grass and forb production on the Utah tracts (pounds/acre)

Year	Sagebrush/Greasewood	Juniper	Shadscale/Sagebrush	Riparian
1975	456	34	2,000	5,265
1976	187	2	34	273

Forage production is also affected by grazing pressure which is affected by weather conditions. For example, Colorado Tract C-b is located within the normal winter mule deer range, while Tract C-a, being at a higher elevation receives more snow and is less frequented by deer, except during mild winters. The winter of 1976-77 had below average snow depth, while the winter of 1977-78 had above average snow depth. These conditions together with severe 1978-79 winter weather has nearly halved the estimated deer population and significantly affected forage utilization.

Consumption of recent years' growth of three shrub types (mountain mahogany, serviceberry, and snowberry) on the two Colorado tracts is shown in Table 10. Browse utilization in excess of 50-60 percent damages a shrub's ability to survive if continued year after year. Thus heavy deer browse use under adverse weather conditions is part of the natural biotic trends of the region and quite unrelated to oil shale development.

Table 11. — Shrub utilization on Colorado tracts by wintering deer

Location	1976-77 (mild winter)	1977-78 (severe winter)
Tract C-a	60-83%	29-67%
Tract C-b	60-80%	90%

Growing conditions during 1979 caused an epidemic of the juniper-hawthorne rust on virtually all serviceberry shrubs in the Piceance basin (Figure 66). Climatic conditions that caused the outbreak are not fully understood. Rust caused early leaf kill typified by serviceberry bushes turning brown near the end of July. Fortunately the rust did not kill the plants, although it undoubtedly weakened them. It will not be known until summer of 1980 if the rust outbreak contributed to unusual plant mortality.

Terrestrial Fauna

Terrestrial fauna of the Piceance and Uinta basins is typical of the pinyon-juniper ecosystem. Large mammals include deer with some elk

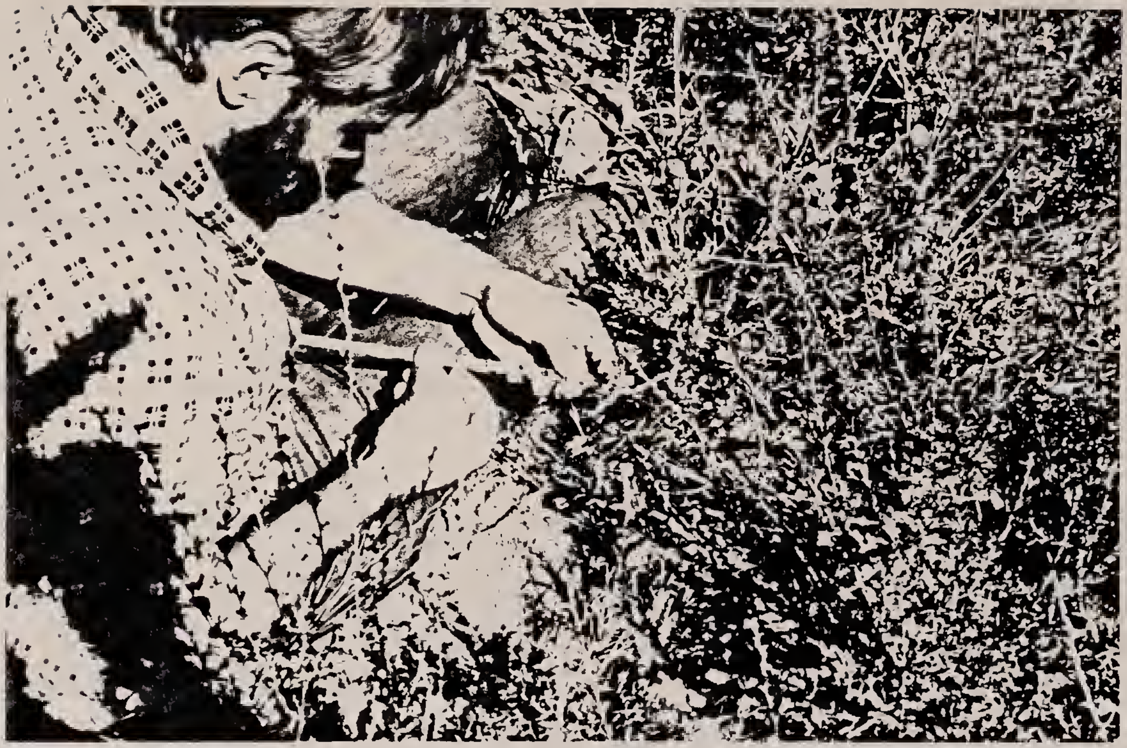


Figure 65. -- Photograph showing measurement of shrub productivity as monitored on Tract C-b by measuring the length of leader growth on preselected shrub samples. Total productivity can then be calculated.

Figure 66. -- Photograph showing the long tentacles on the under surface of a Mountain Mahogany leaf typical of juniper-hawthorne rust which was epidemic in the Piceance basin in 1979.

present at higher elevations. Feral horses are frequently observed in the vicinity of Tract C-a often within a mile of the Mine Development Area. Small mammals present include coyotes, rabbits, ground squirrels, and mice.

Monitoring of deer has indicated a downward trend in total population. This trend is substantiated by Colorado Division of Wildlife figures which show a drop in deer population from 40,000 to 35,000 deer in the Piceance basin in 1978. The severe winter of 1978-79 resulted in a further drastic reduction. Final data is not yet available, but preliminary estimates suggest the population reduction could be as high as 50 percent. Counts of doe:fawn ratio also show marked change along the Piceance Creek indicating a drop from 65 fawns per 100 doe in April 1978 to 12 fawns per 100 doe in April 1979. This further indicates an extreme winter kill. On the other hand, road kills of deer along the Piceance Creek have remained quite stable at 125 for 1977-78 and 131 for 1978-79.

Small mammal populations have remained relatively stable on all tracts. No apparent trends are indicated by field data nor has monitoring found any trends which can be attributed to oil shale development.

Avifauna

The number of bird species on the prototype tracts is quite large. The numbers of birds of a given species, however, is low due to the arid conditions. Birds tend to be highly mobile in a desert environment in order to follow their food supply. This is in contrast to more productive areas where birds may spend many months in a restricted locale. On the Colorado tracts, pinyon-juniper woodlands have consistently supported a more diverse number of bird species than other vegetation types. The riparian area along the White River adjacent to the Utah tracts has roughly twice as many species (68) as other vegetation types on the tracts.

Monitoring has underscored the high mobility of bird populations in response to environmental conditions. Seed-eating birds peak in abundance during July and August. On a year-to-year basis their abundance is directly tied to vegetative production. In drought years, very few seed-eaters take up residence.

Flying insect-eating birds, such as nighthawks, closely parallel the seed eaters in their response to environmental conditions. Again when rainfall is average or better this produces an abundance of insects and an upswing in the bird population that feeds on them. On the other hand, tree and brush insect eaters, i.e., fly catchers and warblers, tend to maintain stable populations on a year-to-year basis showing less sensitivity to rapid environmental shifts.

Fluctuations in avifauna population to date appear to be related to natural changes in annual precipitation. No impacts have been detected which can be directly attributed to oil shale development.

Aquatic Organisms

Aquatic environments in the Piceance and Uinta basins are severely restricted due to the arid climate. Only a few perennial streams exist near the oil shale tracts. The ephemeral streams are small and alkaline. Few man-made ponds are present.

Although the White River is a fast flowing stream draining both the Piceance and Uinta basins, it is not regarded as a good fisheries downstream of the confluence of Piceance Creek. A few trout do exist in intermittent ponds in the vicinity of Tract C-b and in the main stem of Piceance Creek above Tract C-b. Piceance Creek below Tract C-b is essentially devoid of game fish. This is due primarily to lack of suitable stream bottom conditions for reproduction and to irrigation diversion which during low-flow periods either dries up or severely diminishes flow in long stretches of Piceance Creek. The benthos and periphyton organisms present are indicative of alkaline water.

The White River further deteriorates in aquatic habitat quality from the mouth of Yellow Creek in Colorado past the Utah tracts. High turbidity in the reach adjacent to the Utah tracts restricts growth of aquatic flora and fauna. Benthos and periphyton are most prevalent in eddies and backwater areas as opposed to main stream where the scouring action of suspended sediments limits their number. Red shiners and flannel mouth suckers are the most common fish present. The habitat along the White River changes from more mesic pinyon-juniper above the junction with Yellow Creek to an exeric salt desert shrub complex in Utah. The reduction in vegetative cover contributes to an increased silt load in the river. Monitoring has detected no impacts attributable to oil shale development.

Endangered Species

No specific monitoring system is employed for threatened or endangered plant or animal species due to their low probability of occurrence. Tract biologists, however, are constantly watching for listed species. Should they be found, monitoring would be started to determine their abundance.

Although, no endangered species have been found on the tracts, several have been found nearby. One plant proposed for endangered listing by the U.S. Fish and Wildlife Service, (Astragalus Lutosus), was observed near Cottonwood Spring south of Tract C-a in 1975. Sandhill cranes, (Grus canadensis), have been sighted on 84 Mesa and at Stake Springs Pond near Tract C-a. Each time they were sighted it was during their migration period and a cold front with high winds was passing through the area. The wind may have forced the birds down. To be considered endangered under Colorado law, the Sandhill cranes would have to be nesting in the area. A prairie falcon was also sighted in 1975, but none have been seen since. This falcon was apparently migrating south at the time. Bald eagles were sighted several times during 1978 flying in the vicinity of Tract C-b. The eagles were apparently migrating through the area and did not nest or winter on or near the tract.

No threatened or endangered plant or animal species have been sighted on the Utah Tracts. Peregrine falcons have been sighted nearby, but no nests have been found. The Colorado squawfish and humpback chub are thought to exist in the White River near the Utah tracts.

Wildlife Management

The lease requires submission of wildlife management plans as part of the DDPs'. Since the lessees have no authority to actually manage wildlife, the required plans pertain to habitat management. These plans describe how habitat disturbance will be minimized or mitigated including prompt revegetation of disturbed areas (Figure 67) to minimize habitat loss. On Tract C-b, the lessees have also fertilized three areas to increase vegetative productivity (Figure 68). To further offset habitat loss on cleared construction areas, two areas of tall sagebrush in Gardenhire and Oldland Gulch north of Tract C-b have been roller chopped to kill the sagebrush and reseeded with cool season grasses to increase the amount of early green feed available to deer. By drawing deer to these areas, instead of the hay bottoms along Piceance Creek, the lessees also hope to reduce the number of road kills of deer.

To help minimize road kills of deer, Tract C-a lessees have initiated extensive car and van pooling for employees living in Rangely, Meeker, and Rifle. The objective is to limit the number of vehicles on narrow county roads at shift changes. For the same reason, Tract C-b employees living in Rifle and Meeker are transported to the tract in company operated buses from special parking areas established in each community.

Scientific, Cultural, and Aesthetic Values

Scientific and Cultural

Development of the oil shale tracts will result in significant surface disturbance and modification. Protective measures are being taken as required by Federal and State regulations to prevent destruction of sites and objects of historic and scientific value. Compliance is achieved by a search of the literature, public files, contact with the State Historic Preservation Office, search of the National Register of Historic Places and completion of a 100 percent land survey for cultural resources within areas to be disturbed. Based on the field evaluation, a report is compiled on the cultural resource of the area, including an inventory of cultural sites, and an evaluation of their importance.

Preservation of identified values is carried out by avoiding disturbance of recognized sites, whenever possible. Where avoidance is impossible, the affected areas are salvaged by qualified cultural resource personnel. All artifacts to be removed are mapped, recorded, and curated by an approved institution before they are removed.

Lessees must notify the AOSS of any cultural resources discovered as a result of operations under the lease, and must leave them intact until until the site is properly evaluated.

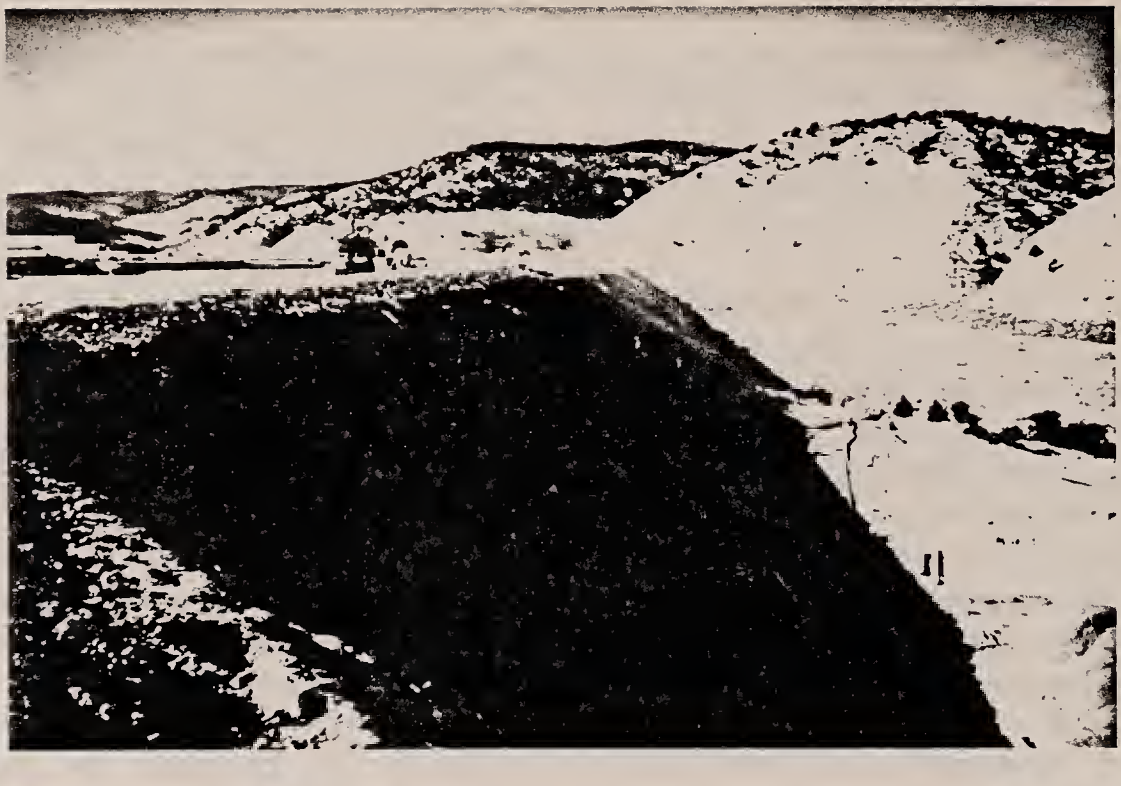


Figure 67. -- Photograph of hydro-mulch revegetation of the steep slopes at the Tract C-a mine development area. The hydro-mulcher which blows a slurry of wood pulp and seed onto the surface.

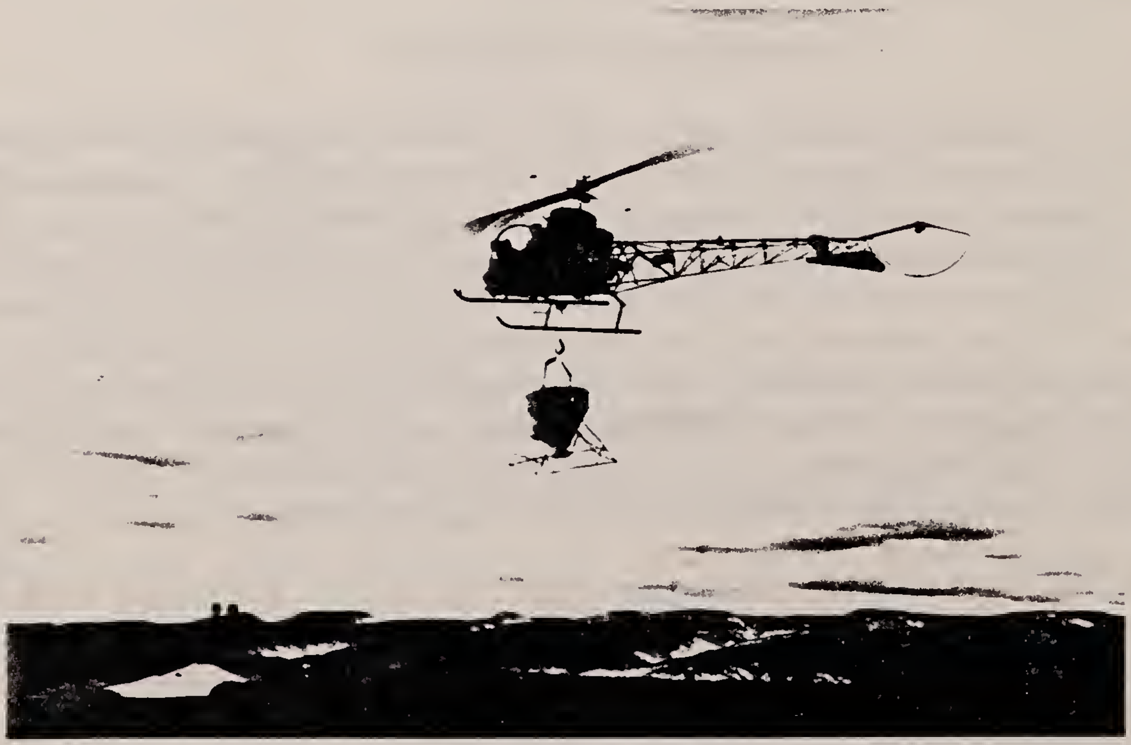


Figure 68. -- Photograph of helicopter spreading fertilizer on rangeland on Tract C-b to enhance forage production to compensate for land disturbed by construction.

The cultural resource inventory carried out on and within a one-mile perimeter of each oil shale tract, indicated the existence of four individual sites and two site clusters. The site clusters may, because of their size, have some historic significance. The archaeological finds were mostly isolated, and individually insignificant and of little historic value. Some sites may have existed in areas on and near Tract C-b before vegetation was chained down by BLM in the late 1960's to improve range forage production.

The general consensus of professional cultural resource people is that the tract areas were not heavily used by early man. Although they moved through this area, it was not on a regular basis nor did they leave many artifacts or structures. What has been found, relates mostly to hunting expeditions.

Scenic and Aesthetic Values

Area encompassing the Federal tracts is not noted for its outstanding scenic or aesthetic values. It was recognized, however, that any area will have some appeal to some people. Lease requirements dictate the protection of scenic and aesthetic values, however limited they may be. Several methods have been tried in an attempt to quantify scenic value and visual impact of development activities including visual quality assessment methods prepared by the BLM and U.S. Forest Service. These studies have concluded that the tracts generally lie outside of the public viewing area due to restricted access and intervening terrain that blocks visual paths from existing public roads. Nevertheless, the integrity of scenic values have and will be protected by using color complementing buildings, contouring stockpiles and disposal areas to blend with surrounding terrain, and by keeping disturbance of natural vegetation to a minimum.

Health and Safety

Lessees of Tracts C-a and C-b have set up comprehensive health and safety training and monitoring programs which include: adequate and continuing training for each employee; investigation and documentation of accidents; daily inspections of work sites, materials, equipment, and work methods for safe performance and regulatory compliance; establishment of tract-wide fire prevention program; obtaining all applicable H&S permits and licenses; and safety indoctrination of visitors, vendors, and others doing business on-tract.

Around-the-clock emergency medical service is provided by paramedics and supervisory personnel certified as Emergency Medical Technicians (EMT's). Each tract also maintains fully equipped field ambulances for medical evacuation to regional hospitals. Severely injured persons can also be transported by helicopter to nearby community hospitals from on-tract helipads or by fixed winged aircraft from dirt strips within a few minutes drive of each tract.

For 1979, Tract C-a reported 537,358 manhours worked with 25 lost-time injuries and no fatalities for an incident rate of 9.3. A contained fire in July destroyed a shower trailer. On-tract emergency staff consists of four EMT's, five safety inspectors, 18 senior supervisors, and four mine rescue personnel, equipped with two ambulances and one fire truck.

For 1979, Tract C-b reported 524,891 manhours worked with five reported accidents (four of which resulted in lost time injuries) and one fatality on August 6, 1979, when a miner was killed by a falling muck bucket at the bottom of the Service Shaft, for an accident frequency rate of 1.91. On-tract emergency staff is similar to that serving Tract C-a consisting of two paramedics, six EMT's, mine rescue personnel, equipped with one field ambulance and a water truck that can double as a fire fighting unit.

The Federal Mine Health and Safety Administration, the Colorado Division of Mines, and contractor safety personnel regularly inspect all tract facilities and issue citations for unsafe working conditions and practices. AOSO personnel carrying out weekly inspections are also alert to situations of eminent danger to life and the environment with authority to suspend any or all operations on-tract until dangerous conditions are corrected.

Socioeconomics

The oil-shale lease tracts are located in sparsely populated rural agricultural/grazing areas of northwestern Colorado and northeastern Utah. The following discussion will focus on Colorado, because of the current inactivity on Tracts U-a and U-b.

A special census in 1977, which was partially funded by the USGS, showed a total population of 101,501 in Garfield, Mesa, Moffat, and Rio Blanco counties of Colorado. This is an area of approximately 14,303 square miles (3.7×10^4 km^3) with seven persons per square mile (2.7 per km^2) encompassing the Federal Lease tracts and the principal area of socioeconomic impact.

The EIS for the POSLP recognized that a major impact of oil shale development was the direct and indirect effect on the social and economic environment. Housing and municipal facilities or services were identified as significant problems. Cognizant of this, the AOSO has encouraged the lessees to cooperate to the fullest extent possible with local, county, State, and Federal agencies with respect to socioeconomic concerns. Both the AOSO and lessees participate in local Impact Mitigation Task Force meetings, where local agencies attempt to identify and resolve socioeconomic problems.

The lessees, upon the recommendations of the AOSO and OSEAP, prepared socioeconomic assessment reports to accompany their DDP's and to assist in local planning efforts. Tract C-a lessees funded a master plan for the town of Rangely and provided community development expertise to town planners. Tract C-b lessees funded separate development guides and other planning documents for the communities of Meeker and Rifle. C-b lessees are also funding a workforce and community data monitoring program as a continuing source of socioeconomic information, and providing quarterly reports to the AOSO which summarize the results of that program. The lessees have also provided frontend money to local developers for construction of a total of 98 apartment units in Meeker and Rifle, and have negotiated for construction of a total of 128 trailer spaces in Rifle and Rangely. These facilities are now 80 percent occupied by tract employees.

Direct expenditures by the lessees of the two Colorado tracts for community planning and funding assistance has totalled more than $1.2 million. These monies are in addition to the 37½ percent (approximately $74 million) of the oil shale lease bonus bid payments that have been returned by the Federal government to the State of Colorado for use in mitigating socioeconomic impacts. Through 1979, about $40 million has been appropriated from the Oil Shale Trust Fund established by the State with returned portion of bonus bid payments.

Peak total daily combined workforce on Tracts C-a and C-b of 575 employees occurred during the fall of 1978. By the end of 1979, total combined workforce had decreased to about 475. About 13 percent of these employees are considered permanent, while the other 87 percent hold construction or temporary jobs. About 53 percent of these workers reside in Rifle, 17 percent in Meeker, and the remainder in other communities of western Colorado principally along the Colorado River valley. The majority of the workforce is living in single family homes (48 percent) and apartments (25 percent) with most of the remainder in mobil homes (20 percent). The average family size is statistically 2.9, or three persons.

Tract C-b provides bus transportation for their employees from Meeker and Rifle. Most tract C-a employees are carpooling or ride in vans provided by the various contractors.

ECONOMIC SUMMARY

Bonus Credit

As of December 31, 1979, lessees of the two Colorado oil shale tracts (C-a and C-b) have paid the first three of five bonus bid payments, or $196,856,760.24, for the right to develop oil shale and associated mineral resources beneath the leased tracts. Of this amount, 37½ percent or $73,821,060.00, has been returned to Colorado for use as impact funding assistance to affected communities. The first three bonus bid payments have also been made by the lessees of the two Utah tracts (U-a and U-b), totaling $72,422,400. All monies for the Utah tracts, however, are being held in escrow until the court ordered injunction over the State in-lieu land selection case is resolved. No distribution to the State of Utah has been made of their share of the bonus bid payments for impact assistance.

Under lease terms, the last two bonus payments may be fully offset by the lessees with expenditures approved by the AOSO for development of the tracts. By the close of 1979, the lessees of the two Colorado tracts had received offset approval for $82,693,253.09 subject to audit and $62,688,667.48 subject to payback agreement if credited plans and facilities are not actually constructed or used. These approved funds more than offset the fourth and fifth bonus payments. No bonus credits have been approved for the two Utah tracts, as they were placed under indefinite suspension of operations by court ordered injunction prior to onset of any development.

Bonds

Lessees of each of the Federal oil shale tracts must, in accord with lease and other Federal regulations, carry surety bonds appropriate to the level of on-tract disturbance to ensure protection and reclamation of the environment (land, air, water). Each tract is currently bonded to the amount of $300,000, with the lease right of the AOSO to require additional bonding at any time warranted by expanding operations.

Development Costs

Development costs, including environmental control, for 1979 for the two Colorado tracts are summarized in tables 11 and 12. Between $4 million and $6 million were spent annually in obtaining the two years of required baseline environmental data on each tract. Since then, development costs have averaged between $30 million and $40 million annually.

Table 11. -- Summary of 1979 operating costs for Tract C-a

(in thousands)

Engineering, Construction and Development:	
Sewage and Seepage Plants	$ 80
Dewatering	486
Site Work	1,503
Power Plant	162
Process Facility	9,593
Shaft, Hoist and Headframe	4,080
Mine Services	5,129
Drifting, Retorting	1,368
Operations	2,830
Managing Contractor Services	3,784
Technological Design	4,152
Environmental	571
Other	281
Total Development	$34,019
Administrative:	
Staff Costs and Overhead	$ 2,461
Consultants	167
Commercial Planning	8
Total Administrative	$ 2,636
Total C-a Project	$36,655

From: Rio Blanco Oil Shale Company, 1979 Annual Progress Report.

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Table 12. — Summary of 1979 operating costs for Tract C-b
(in thousands)

Engineering Design & Construction:	
Preliminary & Engineering Design	$ 4,818.8
Headframe Construction	1,100.2
Shaft Construction	12,521.4
Site Preparation	143.6
Engineering Services and Fees	462.4
Dewatering & Irrigation System	1,465.9
Mining Services	1,103.1
Busing	526.7
Misc. Costs	839.3
Total	$22,981.4
Operating Costs:	
C-b Tract Operations and Maintenance	$ 190.2
	190.2
Environmental:	
Monitoring	
Air	114.0
Water	380.0
Noise	5.0
Geology	.9
Biology	65.2
Photography	4.3
Reporting	29.2
Permits	35.5
Water Resource Development	100.9
Toxological Study	3.6
Reclamation	10.5
Misc. Costs	.7
Total	749.8
Offsite Development:	
Housing	(158.7)
Community Development	279.7
Total	121.0
General & Administrative:	
Staff Costs	2,978.6
Office Expense	404.8
Legal & Professional Fees	197.8
Insurance	429.2
Safety & Security	79.3
Other General & Administrative	1,304.9
Total	5,929.0
Total C-b Project	$ 29,971.4

From: Cathedral Bluffs Shale Oil Company, 1979 C.B. Annual Report.

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